West Africa Rice Development Association

CGIAR

Annual Report 1998

About the West Africa Rice Development Association (WARDA)

The West Africa Rice Development Association is an autonomous intergovernmental research association with a mission to contribute to food security and poverty eradication 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.

In collaboration with the national agricultural research systems of members states, academic institutions, international donors and other organizations, the work of WARDA ultimately benefits West 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 was formed 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). It now 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.

WARDA is a member of the Consultative Group on International Agricultural Research (CGIAR), a network of 16 international research centers supported by more than 45 public- and private-sector donors.

Donors to WARDA in 1998 were: the African Development Bank, Canada, Denmark, the European Union, FAO, France, 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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Association pour le développement de la riziculture en Afrique de l'Ouest

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Cover: The thresher–cleaner (ASI) in action in the Senegal River Delta, Senegal

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

PARTNERSHIPS ARE one of the mainstays of WARDA's success, and one of our most profitable has been that with our national partners (NARS) through the Task Forces. The past year has seen major steps in the evolution of the Task Forces. The First WARDA/NARS Experts Committee Meeting in January included discussion of the recommendations of the 1997 USAID review of the Task Forces. The meeting recommended that the Task Forces be given a new focus on technology transfer, that the three breeding Task Forces be merged into one, and that the Cropping Systems and Problem Soils Task Forces be combined into a single Natural Resource Management Task Force. The Committee also recommended that steps be taken to harmonize the Task Forces with the CORAF Rice Network, especially since the composition of the WARDA National Experts Committee was almost identical to that of the CORAF Executive Committee. A subsequent meeting between CORAF and WARDA in August led to a proposal that the two networks be merged into a single rice research network for West and Central Africa. The modalities of this new network are being discussed even as we write this report. We take this opportunity to look back over the evolution of the Task Force mechanism, as well as into the future (page 9).

The last year saw the departure of Interim Director of Programs, Willem Stoop, and the arrival of Amir Kassam to take up post as Deputy Director General for Programs—thus completing the new WARDA management team. Before joining WARDA, Dr Kassam was at the TAC Secretariat for nine years. He brings a wealth of CGIAR programmatic and strategic experience to WARDA. Brent Simpson arrived to head the Technology Transfer Program, and the Program Committee was strengthened in its role of research planning and review. Additional new faces at WARDA are George Maina (Head of Finance), Olumuyiwa Osiname (WARDA's Interim Coordinator in Nigeria, based at Ibadan, Nigeria), Guy Manners (Information Officer), Thierry Cadalen (Molecular Biologist, Post-Doctoral Fellow), Satoshi Tobita (Physiologist/Molecular Biologist, JIRCAS), and Wilfried Hundertmark (Water Management Specialist, IWMI).

WARDA's new Deputy Director General for Programs, Amir Kassam, with Director General, Kanayo F. Nwanze

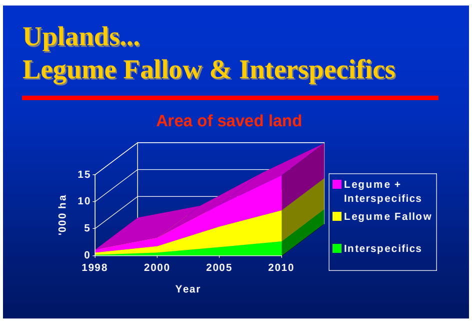
Another caliber of staff joined WARDA in 1998, when we introduced a Visiting Scientist Scheme, whereby NARS scientists can be posted to work as part of the WARDA team at one of our stations. The positions are open to full-time national scientists nominated by their respective institutions. During the 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.

The first year has been an encouraging success, with an Agronomist/Breeder from Senegal and an Entomologist from Nigeria working at Headquarters, and a Breeder from Burkina Faso working at the Sahel Station. The work of the Agronomist/Breeder, Amadou Moustapha Bèye is featured in this report (page 40).

Obtaining relevant and up-to-date information has been a problem throughout much of West and Central Africa for many years. We are pleased to have been the instrument by which many of our NARS and extension partners have been able to cash-in on the benefits of global communications through the Internet. As the first phase of the AfricaLink project draws to a close, we summarize the progress to date, and look forward to improved interaction with our partners through electronic-mail, Web-based discussion fora, and rapid information dissemination (see page 45).

The year also saw an expansion of our partnerships with regional and national development agencies, such as ANADER and Projet riz nord in our host country Côte d'Ivoire (see page 40), and SAED and AGETA in the Sahel (see page 16). Such partnerships are often only part of broader linkages encompassing farmers' groups, NGOs and the private sector—several of which are highlighted in this report. Our pivotal role in fostering partnerships throughout Sub-Saharan Africa was demonstrated when the Director General was asked to chair a joint Task Force of the Forum for Agricultural Research in Africa (FARA) and the World Bank's Special Program for African Agricultural Research (SPAAR). This Task Force was mandated to develop a vision (document) on Agricultural Research in Sub-Saharan Africa.

Natural resources are often viewed in very narrow terms, principally as soil, water and biodiversity. In recent discussion arising from the Third System Review, the CGIAR Centers have provided a more accurate, and broader, definition of natural resources to encompass all those elements generated by natural processes; that is, soil, water, the atmosphere, animal and plant life. In this context, crop improvement has a valuable role to play in the conservation of natural resources, especially land (soil) and water. The graph illustrates the amount of land projected to be saved by the use of WARDA's 'new rice for Africa' and legume–rice crop rotations to the year 2010—that is, the amount of extra land that would have to be brought under production if these options are not adopted. This is just one aspect of natural-resource management; others are illustrated in the following features, especially our work on soil fertility and fertilizer management in the Sahel (page 16) and weed management (page 32).



This year sees the introduction of a new feature, a *Donor Country Profile*. The first profile focuses on Japan as an example of a donor with strong collaborative research activities, including the posting of scientists to work with us at our Headquarters (page 48). Other donors highlighted in this report are France and the Netherlands (IVC, page 23), the UK (weed research, page 32), and the USA (Task Forces, page 9).

The past year saw further evolution of WARDA's mission in line with the revised mission of the CGIAR as a group, and in preparation for a revised Medium-Term Plan for the period 2000–2002. Our redefined mission is:

> ***"to contribute to food security and poverty eradication 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."

Highlights of the year at WARDA included the release of a video, in English and French, on our successful development of a new, robust and resilient plant type from our Interspecific Hybridization Project (IHP), entitled *Bintu and Her New African Rice*. It describes the advantages of the new rice for Africa, and tells the story of a typical West African woman farmer participating in WARDA's Participatory Varietal Selection scheme and her appreciation of the interspecific lines. The work in Guinea progressed with the NARS establishing and operating their own Participatory Varietal Selection following the WARDA model. Progress in Benin, Ghana, Nigeria and Togo has been more modest, but has confirmed the many advantages of Participatory Varietal Selection approach in generating and disseminating technologies as a fast-track to responding to farmers' own identified needs and opportunities. Côte d'Ivoire demonstrated its confidence in us by releasing no less than eight WARDA-generated rice varieties in 1998. Meanwhile, the impact of the IHP spread beyond Africa, as IRRI started screening some of the new lines in Asian toxic soils in savanna ecosystems and developing other progenies for rainfed upland systems in South and Southeast Asia.

Looking ahead, the biggest single challenge that we may have to face in the near future is the major transformation of the agricultural agenda in many Sub-Saharan African countries. Are we well balanced and poised to face the challenge of increasing the competitiveness of locally produced rice against cheap imports? Increased rice production alone will not result in food security. An integrated approach which considers all capital assets—social, physical, financial, commercial, human and natural resources—in a dynamic and multi-functional system will be required. WARDA's work is only one facet of this system and the drive for agricultural and socio-political security. We believe that today we are strategically positioned to contribute to the process of achieving this goal.

Lastly, a few words to our stakeholders. WARDA continues to enjoy its unique institutional context as an association of member states, while also being a part of the international network known as the CGIAR. The Association was created by the political will of its member states, and has developed into a shining example of regional integration. By its international nature (in part through the CGIAR), WARDA is also a good example of South–South and North–South collaboration in global agricultural research and development. The success of much of our research and development work in recent years has led to increased demands on our resources, not only from West Africa, but from throughout Sub-Saharan Africa and beyond. These demands require adequate support. We believe that WARDA's role in the global context is multifaceted within our overall mission to increase rice production in an environmentally friendly and sustainable way for the benefit of rice producers and consumers throughout Africa in the drive for regional food security and poverty eradication.

Kanayo F. Nwanze
Director General

Just Faaland
Chairman, Board of Trustees

WARDA under a New Program Structure

Amir Kassam
Deputy Director General for Programs

IN 1997, WARDA proposed a restructured program in its 1998–2000 Medium-Term Plan (MTP). Under this new program structure, WARDA's research and related activities were regrouped into a set of projects under four programs: 1. Rainfed Rice Program; 2. Irrigated Rice Program; 3. Policy Support Program; and, 4. Information and Technology Transfer Program, and assisted by Program Support Units covering Biometrics, Information and Documentation, Training and Fellowships, INGER-Africa, Quarantine/Biosafety, and Task Force Coordination. Thus, 1998 was the first year that program activities at WARDA were implemented based on this new structure.

Given the newness of the program structure, its implementation was closely monitored during 1998 from an internal viewpoint as well as from an external collaboration angle. The most important internal aspect was the balance in terms of project activities among the four Programs. An internal assessment of scope and size against the need for a dynamic research process along the research-to-development continuum, showed that the technology generation Programs 1 and 2 should not be expected, as perhaps thought originally, to accommodate the research required for evaluation and further development of promising technologies within the broader context of targeted production systems in the different agro-ecologies. At the same time, the scope of Program 4, as originally defined, proved to be narrow and needed to be widened to accommodate the future technology evaluation research for systems development to complement technology transfer activities. These issues were discussed by management and Board in June and November 1998, and during the initial phase of WARDA's Annual Review and Planning Meeting in December 1998. As a result, it was proposed that for the MTP 2000–2002, the title of Program 4 should be changed to *Systems Development and Technology Transfer* and the project portfolio be expanded from three projects to five to accommodate technology evaluation research and technology transfer for irrigated, upland and inland valley systems. More information on this proposed revision to the program structure will be provided in the 1999 Annual Report.

The most important external aspects, based on the consultation with the member countries at the WARDA–National Experts Committee meeting in January 1998 and with CORAF in August 1998 were: the operationalization of the technology transfer activities of Program 4, and the future harmonization of WARDA Task Forces and CORAF Rice Network. Excellent progress was achieved in resolving these issues. For technology transfer, it was clearly recognized that while WARDA has no comparative advantage in becoming involved in direct extension activities, there is a need to link up with other stakeholders who have such an advantage. WARDA's role would always be that of a "facilitator of stakeholder coalitions" of various kinds when it came to the wider dissemination of technologies generated by WARDA and its partners.

Concerning the harmonization of the WARDA Task Forces with the CORAF Rice Network, an important milestone achieved in 1998 was the decision by CORAF and WARDA to merge these two entities to create a unified Regional Rice Network. After two joint meetings between CORAF and WARDA, it was agreed to harmonize the two mechanisms, and begin the implementation, under the Task Force mode, of a unified Regional Rice Research and Development Network in 1999, with a Network Secretariat hosted by WARDA. The potential benefits of this development in regional cooperation, in terms of technology evaluation and dissemination as well as strengthening regional rice research capacity, are immense.

The Inland Valley Consortium stakeholders, including WARDA and CORAF, devoted considerable energy during 1998 into formulating the Phase II strategic plan for the period 1999–2004. This was achieved through joint planning exercises involving the Consortium member countries and other partners. The two important changes which will feature during Phase II are the closer integration of the IVC into the overall WARDA program (through Program 4, and with linkages to other Programs); and the revised research agenda with a focus on: characterization of land use dynamics, development and evaluation of technologies to improve inland valley production systems and natural-resources management; socioeconomic and policy aspects of improvements in the inland valley land use systems; and technology dissemination processes and impact pathways for inland valley development.

An exciting development at WARDA's main research farm was the creation of a watershed facility for interdisciplinary research to improve of lowland rice cultivation and land use management. Detailed baseline characterization of the biophysical environment during 1998 will form the basis for future research on natural- resources management, some of which will be long term. The watershed facility will also serve the needs of the Inland Valley Consortium.

The year also saw the launch of WARDA's regional training program for NARS on participatory breeding and selection. In May 1998, WARDA organized a 10-day Participatory Rice Improvement and Gender/User Analysis (PRI & G/UA) training seminar for its member countries at WARDA Headquarters. A breeder and a social scientist from the national agricultural research institutes attended the training from each of 10 member countries. The purpose of the seminar was to introduce the scientists to participatory and gender/user analysis methods and tools, as well as to share the knowledge gained from WARDA's PRI & G/UA work. As a follow-up to the 1998 seminar, WARDA scientists have visited most of the participants and provided backstopping for their PRI & G/UA activities. The partners from the 7 remaining member countries who were unable to attend the May 1998 training will receive training in 1999 to enable them to begin PRI & G/A work in their respective countries.

Beyond the above-mentioned accomplishments, and those that are featured in this Annual Report, there were a number of others that deserve mention. These include: the continuing remarkable on-farm performance of the 'new African rices' in marginal environments across several countries; the strengthening of our genetic enhancement activities especially in the areas of interspecific breeding and molecular biology, including the development of transgenic lines (in collaboration with partners in the UK) and marker-assisted breeding; the knowledge of the extent of the serological variability of rice yellow mottle virus (RYMV) in West Africa, and the identification of resistant cultivars to replace popular but susceptible varieties; a scheme for screening durable resistance to blast; the study of the importance of nematodes in rice systems; the development of decision tools for integrated management of pests, nutrient and water; the successful introduction of postharvest machinery in the Sahel; the development of community-based seed multiplication schemes; successful facilitation of the formulation of country-specific biosafety regulations; and the strengthening of Program Support Units, particularly in the areas of genetic resources, information, and modeling.

The further evolution of WARDA's program structure and the accomplishments during 1998 provide ample evidence that WARDA continues to be a sound investment for the CGIAR and a vibrant research center of excellence on the African continent. Its program agenda, aimed at producing international public goods, is not only output driven and demand responsive, but also of high relevance to the farmers and development community in the region. WARDA's interspecific hybridization program, responsible for generating the 'new African rices,' and the associated participatory research and technology transfer approaches, are at the cutting edge of science and are impacting rural livelihoods, particularly those of women and children. WARDA's ecoregional activities are providing strong leadership in systems development and natural-resources management in inland valleys. WARDA's partnerships with NARS and other collaborators are inclusive and synergistic with direct benefits to all stakeholders. Some of these dimensions are captured in greater detail in the feature articles that follow. We remain confident that WARDA will continue to deliver a high level of performance next year and beyond.

Task Forces: A Successful Mode of Operation with National Partners

THE WARDA Task Forces started in 1991 as a novel approach to building partnerships with the national agricultural research programs of West Africa. In eight years, they have come a long way, and the Task Force approach is being adopted by the unified CORAF/WARDA rice research and development network for West and Central Africa. What have we learnt and where are we going?

The background: early relationships between international centers and their national partners

Conducting agricultural research and development for a region as large and diverse as West Africa is no easy task. Before the inception of the Task Force mechanism, two working groups of national agricultural research representatives were convened to advise WARDA on the development of a suitable framework. These groups identified four crucial issues which had to be addressed in order to ensure the success of any new relationship between an international agricultural research center (IARC) and its national partners (NARS).

First, earlier models had failed to incorporate the needs of NARS when setting priorities for the operation of the IARCs. Research agendas were set by the centers, and interested NARS were encouraged to collaborate. This 'top-down' approach also characterized most of the early IARC-established networks.

Second, international centers often failed to build on the diversity of their partner NARS, either by treating them all as if they were the same, or by working only with those which were stronger or larger. Furthermore, IARC–NARS collaboration was often on a short-term project basis, rather than on an ongoing program basis. Such activities were poorly integrated with the IARC's core program, and the timeframe was often too short to generate any meaningful results. Short-term projects could also be disruptive of NARS' own programs and objectives.

Research results are made available beyond national borders through joint research and research coordination

Finally, IARCs all too often operated with NARS in a bilateral mode: working independently with each NARS.

On the basis of these diagnoses of earlier relationships between IARCs and NARS, the working groups strongly recommended that a mechanism be established to enable research planning on a regional level.

The response: what the Task Forces sought to achieve

In response to these criticisms and suggestions, WARDA set about to institute a research collaboration mechanism to meet the needs and aspirations of its partner NARS—that is, to address the NARS' needs in a 'bottom up' approach, rather than dictating the research agenda 'top down.' For this purpose, the Task Forces have four primary objectives.

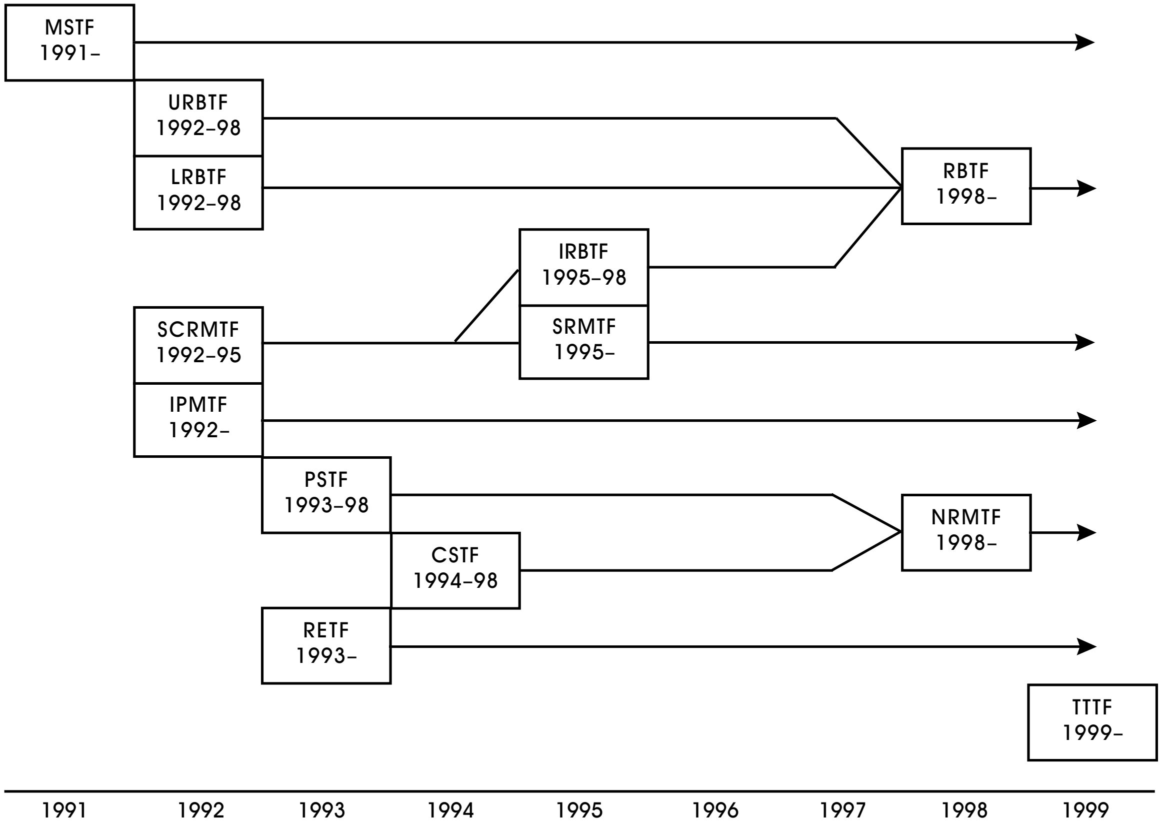
Iron toxicity is a serious problem in many West African countries—originally handled by the Problem Soils Task Force, it is now within the remit of the Natural Resources Management Task Force

- To coordinate regional research activities, thereby reducing duplication and identifying the most efficient utilization of resources among the various rice research programs in West Africa.
- To provide national scientists with more complete and rapid access to research information and results of regional research.
- To transfer and test technologies in a targeted and systematic way.
- To target technical, material and financial assistance to national programs in a way that strengthens the overall regional rice research system.

Task Force activities are designed to address the major constraints to rice production as identified by the NARS. Regional coordination allows the work conducted in one country to be available for application in all the other countries. This negates the need for each country to conduct the same research, thus freeing resources elsewhere for other activities. The resources of individual NARS are not overstretched, but specific tasks are allocated to each country for the benefit of the region as a whole.

During the first phase of the Task Force mechanism, nine Task Forces were in operation (see Figure 1). Membership of a particular Task Force is open to any country in which the target ecosystem or research focus is important for rice production, and which has at least one scientist active in that area of research. The national participants are nominated by their NARS directors. The Task Forces are designed to operate with a minimum of administration and bureaucracy. Each Task Force has a Steering Committee, which is chaired by one of the national scientist members, and a WARDA scientist acts as secretary and provides coordination to the Task Force as a whole.

Figure 1. Evolution of the WARDA Task Forces



Task Forces (TF) acronyms: CS = Cropping Systems; IPM = Integrated Pest Management; IRB = Irrigated Rice Breeding; LRB = Lowland Rice Breeding; MS = Mangrove Swamp; NRM = Natural Resource Management; PS = Problem Soils; RB = Rice Breeding; RE = Rice Economics; SCRM = Sahel Crop and Resource Management; SRM = Sahel Resource Management; TT = Technology Transfer; URB = Upland Rice Breeding.

Modi operandi: coordinating regional rice research and capacity building

The Task Forces act as coordination units for WARDA and NARS research focused on regional issues. As such they essentially operate in five ways: meetings; joint research activities; monitoring tours; visiting fellowships; and training.

The members of each Task Force meet once a year to present and discuss their results from the previous year, and to plan activities for the following year. For many Task

Joint research activities are a major component of the Task Force mechanism

Force members, these meetings are at the heart of the Task Force mechanism. It is here that researchers from the various NARS and WARDA meet together to plan their research activities as a joint exercise. Scientists that for most of their careers and most of each year work in isolation, are brought together with their peers—the meetings allow exchange of experiences and information among partners who might otherwise never meet each other. Mohamed Kebbeh, Head of Socio-economic Research at the National Agricultural Research Institute (NARI), The Gambia, and member of the Economics Task Force since 1997, is a strong supporter of the Task Force for this very reason: "Researchers from the same discipline, but from different countries, are brought together by the Task Force for interaction that otherwise would not have occurred. This is highly beneficial as we learn a lot from our interactions with NARS that are stronger in specific areas."

Proposals for projects submitted to the annual meeting need the prior approval of the director of the executing NARS institution. Resources are allocated to projects selectively (there are usually more proposals than funds available) by the Task Force's Steering Committee, based on the priorities for research identified in the consultation process. Here, again, the Task Force provides strength in the form of research collaboration. "Proposals which require strengthening," explains James Edwin of Rice Research, Rokupr, Sierra Leone, and Chairman of the Economics Task Force since its inception in 1993, "are discussed by Task Force members from various countries. Strengthening of the proposal [improving its chances of being funded] is provided by the inclusion of collaborative activities across two or more countries."

During monitoring tours, NARS and WARDA scientists discuss crop problems with farmers in the field

Monitoring Tours are conducted to specific ecosystems in selected countries. For these tours, Task Force members and WARDA scientists constitute a multidisciplinary team, which seeks to verify that the Task Force research priorities are still valid. Essentially this amounts to verifying the importance of existing target constraints and identifying any new issues requiring research input. The tours include visits to Task Force trials and discussions with farmers to understand their perception of the constraints to rice production and to identify opportunities for technology generation, adaptation and transfer. Dakoua Dona, Entomologist and Rice Program Leader in Burkina Faso, and member of the Integrated Pest Management Task Force since 1995, finds monitoring tours particularly useful: "we see real problems in the field and, even more valuable, indigenous techniques in operation. I particularly remember the first time I saw rice growing on ridges—that was in Guinea Bissau."

A major part of Task Force activities involves training—increasing the knowledge and skills of the NARS researchers in particular. One aspect of this is the Visiting Fellowship program, whereby a NARS scientist goes for individual one-on-one training either to WARDA or to another NARS. This facility is useful where the trainee needs, for example, to learn a particular methodology or the use of a certain piece of equipment, or for data analysis and report writing. Typically, Visiting Fellowships are for one week to three months in duration.

More typical training programs are also run by, or for, the Task Forces. Here, the members of a Task Force, or a selection of members from a Task Force, attend a training course to learn a new skill. By the end of 1997, some 526 scientists had attended such training courses. Task Force members particularly appreciate the availabil-

Variations on a theme

Despite their unification under one set of objectives and modi operandi, the Task Forces have a certain amount of individuality—each drawing together scientists in similar fields to approach rice research with a regional perspective. The emphases and exact operations of the various groups differ so as to make each individual Task Force very much a 'variation on the Task Force theme.' Here are just a few examples.

The Mangrove Swamp Rice Task Force is unique in that it is not coordinated by WARDA, but by the Mangrove Research Station in Rokupr, Sierra Leone. This came about when WARDA management, at the behest of various donors, decided that Mangrove Swamp should no longer be a core ecosystem for WARDA. Most of WARDA's mangrove swamp work had been based at the Rokupr station, and the Sierra Leonian NARS was perfectly poised to take over the station, the research program and the Task Force. Emmanuel Imolehin, Assistant Director of the National Cereals Research Institute (NCRI), Badeggi, Nigeria, and member of the Mangrove Swamp Rice Task Force since its inception in 1991, highlighted the value of the small-grant system "for those NARS whose governments do not give priority to mangrove swamp research." Imolehin also highlights other major benefits of the Task Force: "The exchange of rice germplasm has been invaluable, with Rokupr generating good source material, reducing the need for breeding work in other NARS. The Visiting Fellowship system has also benefitted our Task Force, for example, a group of us went to the NARS in Senegal to learn how to conduct soil analysis."

For Mamadou Kabirou Ndiaye of the Institut d'economie rural, Mali, and member of the Sahel Resource Management Task Force since 1994 and Interim Chairman since 1997, the highlight has been the knowledge gained from the interaction with Sahel-based rice researchers across the region. "At a meeting of the Unité de recherche pour le développement observatoire de changement (URDOC) (a French project based in the Office du Niger rice-growing area), the producers stressed that they were having problems with threshing their produce. Because I was a member of the Task Force, I knew about the thresher–cleaner that had been developed in Senegal, so I was able to contact WARDA for assistance. We now have a prototype under testing in Mali."

The Integrated Pest Management Task Force is a multidisciplinary group of entomologists, pathologists, virologists, weed scientists and nematologists that meets together rather than in discipline-oriented groups. Their aim is to generate technologies to form integrated pest management options suitable for promotion among farmers. Where diversity within pest populations is a key issue, pests (blast, rice yellow mottle virus and African rice gall midge) are tackled through coordinated experiments on a region-wide basis. For other pests, such as weeds and nematodes, responsibility for research is taken by individual NARS and the results shared throughout the region. These efforts have led to a great improvement in the knowledge that is available to the regional rice researchers, and is now forming the basis of integrated pest management approaches.

Blast is a major rice disease throughout the sub-region and therefore a focus of regional Task Force activities. Here is a Task Force screening trial for blast resistance—the variety in the foreground is clearly not resistant!

Dogbé Selome of the Centre de recherche agricole of the Institut togolais de recherche agricole (CRA/ITRA, Togo), and member of the Breeding Task Force since the inception of the Lowland and Upland Breeding Task Forces in 1992, tells that members of the Breeding Task Force particularly benefit from the distribution of new plant material in nurseries—material originating both in WARDA and in the various NARS. He also stresses the importance of other aspects of the mechanism: "in Togo, there is insufficient funding for national scientists to conduct research; the small grants provided through the Task Force at least enable us to do something! We have also benefitted in our work by learning tissue-culture techniques from WARDA, again through the Task Force."

Through the Breeding Task Force, WARDA was able to modify the composition of INGER nurseries to make them more specific and targeted to NARS needs. In the early days of the International Network for the Genetic Evaluation of Rice (INGER), a few nurseries were composed for wide distribution. These nurseries had fixed composition in terms of entries, although they were a 'mixed bag' of plant types. These were sent complete to all participating countries, regardless of their capabilities to handle the number of entries provided. Through the Breeding Task Forces, INGER-Africa asked the various NARS what they wanted in terms of plant types (duration, grain type, stature, stress resistances and tolerances) and number of entries. In this way, they were able to target the specific needs of the individual countries, by supplying germplasm which had the required characteristics. To date, many varieties promoted through the Task Force/INGER nurseries have been released in various countries within the sub-region (see Table 1).

Table 1. Rice varieties released by WARDA member states, most were promoted through the Task Force mechanism

Variety	Traits	Country(ies)
Upland rice		
TOX 1011-4-A2	DT, BR	Guinea
WAB 35-2 FX	HYP, BR, DT	Nigeria
WAB 56-39	E, BR, DT	Burkina Faso
WAB 56-50	E, BR, DT	Burkina Faso, Côte d'Ivoire, The Gambia, Guinea Bissau, Liberia
WAB 56-104	E, BR, DT	Côte d'Ivoire, Liberia
WAB 56-125	E, BR, DT	Burkina Faso, Côte d'Ivoire, Nigeria
WAB 96-1-1	WS, LIA	Cameroon, Côte d'Ivoire, Liberia, Sierra Leone
WAB 99-1-1	BR, DR, AT	Côte d'Ivoire
WAB 384-B-B-1-2	HGY	Cameroon
WAB 638-1	A, HGY	Côte d'Ivoire
Lowland rice		
Cisadane (FARO 51)	GMT	Nigeria
WITA 1 (Yabra)	ITT, BR	Côte d'Ivoire, Nigeria
WITA 3 (Kossou)	ITT	Côte d'Ivoire
WITA 4 (TOX 3100-44-1-2-3-3; TGR 203)	ITT, DT, LIA, HGY	Cameroon, Chad, Nigeria, Togo
WITA 7 (Gagnoa)	GQ	Côte d'Ivoire
WITA 8 (Sandela)	VT	Côte d'Ivoire, Nigeria
WITA 9 (Nimba)	E, VR	Côte d'Ivoire, Mali, Niger
Irrigated rice		
BW 293-2 (Sahel 201)	HGY	Mauritania, Senegal
IR 64 (FKR 42)	E, ST, HGY	Burkina Faso
IR 13240-108-2-2-3 (Sahel 108, FKR 44)	HGY, E	Burkina Faso, Mauritania, Senegal
IR 31785-58-1-2-3-3	HGY, E	Mauritania
ITA 306 (Sahel 202)	HGY, GQ	Mauritania, Senegal
S 499 B-28	HGY	Mauritania
WASSA (IR 32307-107-3-2-2)	E, GQ, HGY	Mali
Mangrove rice		
ROHYB 6	MD	Guinea Bissau
ROK 5	HGY, ST, AT	Guinea
WAR 1 (ROK 22)	HGY, ST, AT	The Gambia, Guinea, Guinea Bissau, Senegal, Sierra Leone
WAR 77-2-1-1	HGY, ST, AT	The Gambia, Guinea, Guinea Bissau, Senegal, Sierra Leone

A = aromatic; AT = acidity tolerance; BR = blast resistance; DR = drought resistance; E = earliness; GMT = gall midge tolerance; GQ = grain (eating) quality; HGY = high grain yield; HYP = high yield potential; ITT = iron-toxicity tolerance; LIA = low input adaptability; MD = medium duration; ST = salt tolerance; VR = virus (RYMV) resistance; VT = virus (RYMV) tolerance; WS = weed suppression.

ity of non-research training. A few years ago, many Task Force scientists attended a course run in collaborationwith WARDA on writing research reports. The reaction of Segda Zacherie of the Institut de l'environnement et des recherches agricoles (INERA), Burkina Faso, and Chairman of the Natural Resource Management Task Force since 1996, is typical of many who have benefitted from this particular experience: "the training in scientific writing has been a major component, and the Task Force presentations have been of increasingly high quality since the courses started in 1994. My superiors are now amazed that I am able to publish a new research article on average every six months—most of these are co-written with WARDA scientists—this would not have been possible without the Task Forces. Other networks with which I have been involved only had money for research, not training."

The future: a single regional research rice network

In 1997, USAID reviewed all of the networks that it had been funding, including the WARDA/NARS Task Forces. The review highlighted strengths and weaknesses of the Task Force mechanism, and included identification of areas in which improvements could be made, or where the Task Forces were ready for a change of emphasis.

The First WARDA/NARS Experts Committee Meeting was held in January 1998, and included detailed discussion of the USAID review. Recommendations made by the USAID review and endorsed by the Experts Committee were for the Task Forces to include a new focus on technology transfer, for the three breeding Task Forces to merge, and for the Cropping Systems and Problem Soils Task Forces to be combined into a single Natural Resource Management Task Force. The number and nature of meetings was also a target for reform—there were simply too many meetings! The Experts Committee also recommended that steps be taken to harmonize the Task Forces with the Conférence des responsables de la recherche agricole en Afrique de l'Ouest et du Centre (CORAF) Rice Network, especially since the composition of the WARDA National Experts Committee was almost identical to that of the CORAF Executive Committee and both networks involve the same NARS scientists.

CORAF and WARDA met to discuss harmonization of their activities in August 1998. This led to a proposal that the two networks be merged into a single rice research network for West Africa. At this meeting, CORAF and WARDA agreed on a 'Memorandum of Understanding,' declaring their intentions for future collaboration. A further CORAF/WARDA meeting in Cotonou (Benin) in December 1998 consolidated the commitment to the merger, and stated that the new network will be hosted by WARDA and should follow the Task Forces model. It is suggested that the new network comprise two bodies: a General Assembly and a Steering Committee. An Interim Steering Committee was established at the Cotonou meeting. It is expected that a permanent structure will be put in place early in 2000 at the First Regional Rice Research Review—that is, the first full meeting of the new network.

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RICE IS the only crop that can be grown under irrigation on the saline soils of the Senegal River delta. The parched soils will allow no crops to grow without irrigation. Irrigated rice in the Sahel has great potential: with the abundant sunshine yields can be very high, and there is also the possibility to grow two crops per year. Rice is also the farmers' crop of choice in the other irrigated parts of the region. National governments have invested vast sums of money in irrigation infrastructure, and in the past even relocated populations to the region with the sole purpose of having them grow rice. Rice is essential both for the national economy and for the families themselves.

Despite the high expectations that prompted investment in irrigation, farmers' yields from irrigated rice in the Senegal River delta are generally low (3–5 tonnes per hectare—compared with a potential of 9–10 t/ha) and only 10% of the land is double-cropped. There is great diversity among the farmers of the region—from large commercial organizations aiming to make a serious profit from their fields, right down to subsistence farmers who must raise their families on the output of their rice farming—but many of the difficulties that they face in trying to make their production more profitable and sustainable are the same. One of the basic problems is managing soil fertility—does the soil contain enough nutrients to support the growing crop? If not, what is the best strategy to get the most out of the soil and the crop, without depleting the soil to the extent that the next rice crop suffers?

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Our work is conducted in a partnership mode, and farmers and extension agencies require feedback. What is more, by sharing our results with those who effectively generated them, we get feedback to help improve our research methods in the future. To this end, an end-of-season meeting is held in which the farmers from a particular irrigation scheme which has been monitored throughout the season are brought together with national and WARDA scientists and extension agencies. This constitutes a farm-

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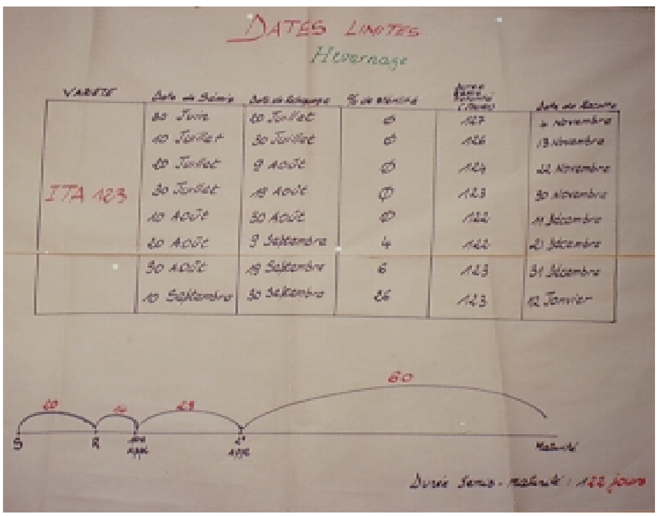

Poster at a farmers' end-of-season meeting showing the effect of sowing date on fertilizer and harvest timing

The final poster is an overview of the whole season across the irrigation scheme. Here we can point out successes and failures, not in terms of 'good' and 'bad' farming, but in terms of farmers facing few or many constraints (problems) to successful production. This usually opens up into a general discussion on finding solutions to the constraints and improving the farming in general. At the end of the meeting, the recom-mendations for fertilizing next season's crop are presented, and will be presented again by the extension agents before the next crop is grown.

Where are we now?

One over-riding result of this research has been that, in general, applying fertilizer to irrigated rice is a good investment—fertilizer application at an appropriate time is beneficial for the crop, and therefore for the farmer. The three graphs (Figure 2) illustrate the case of Guédé in Senegal. We can see that the variability (among farmers) is large, so there is substantial scope for improvement. Improving nitrogen recovery will increase the benefits (that is, economic returns) from fertilizer use. Furthermore, the risks involved with using nitrogen fertilizer are very low—only about 10% of the farmers surveyed lost money through applying the fertilizer.

Our work in the four countries is at various stages, the work in Burkina Faso being the most advanced. Here we have shown that the current practice of applying a compound fertilizer designed for cotton is inappropriate, and have established new recommend-ations for urea and phosphate (in the form of rock phosphate) in the wet season. The use of compost from rice straw is also recommended. For the dry season, we are advising farmers to apply only a reduced dose of urea, since this is the season most prone to crop failure (due to the scarcity of water and temperature extremes) and therefore the

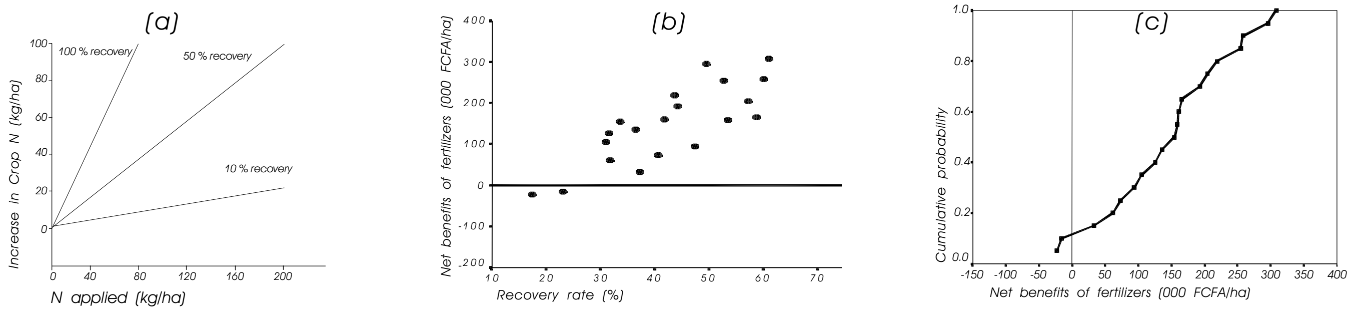

Figure 2. Apparent recovery of fertilizer nitrogen (a), net returns to fertilizer application related to nitrogen recovery rate (b), and probability of benefit to fertilizer application (c) at Guédé, Senegal

AGETA

Sidy Mohamed Ameida, Agricultural Adviser to AGETA, is so happy with the work that WARDA has done with AGETA, that he wants to extend the collaboration. "The farmers we work with fall into three categories based on the size of the irrigation scheme. Each category has different abilities and different expectations. I want us to collaborate with WARDA on evaluating the constraints facing each group, and adapting the latest appropriate technology to these groups. We also need WARDA's input on training." WARDA conducted a general course on rice production for AGETA agents in 1997. "To build on the earlier course," continues Sidy, "we need specific training in fertilizer management, weed control and plant physiology." We see this request as positive feedback on our collaboration to date.

investment may be considered a risk. The fertilizer recommendations are combined with others for sowing dates, age of seedlings for transplanting, and water management in the dry season.

In Mauritania, we have been working with the extension service for 'large' farmers, Association générale des groupements d'exploitants et éleveurs pour l'étude et l'emploi de techniques améliorées agricoles et animales (AGETA) for two seasons. Here, fertilizer recommendations have been combined with weed control recommendations into a package. These combined recommendations increased yields by almost 2 tonnes per hectare over previous cropping practices (see Figure 3). These results are currently being verified in another season of trials.

WARDA started working with the Senegalese extension service, Société d'aménagement et d'exploitation des terres du Delta du Fleuve Sénégal et des vallées du Fleuve Sénégal et de la Falémé (SAED) and farmers in Guédé in 1996. Soil fertility has been monitored ever since. In 1997, WARDA/SAED started trials on the application (rate and timing) of urea and diammonium phosphate. The whole scheme of Guédé became involved in the socioeconomic

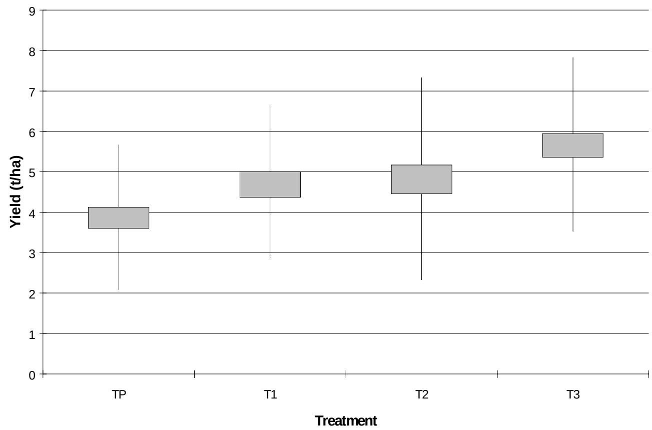

Figure 3. Application of recommended fertilizer and weed-control (T3) gives an average of almost 2 t/ha more grain than the farmers' practice (TP); recommended fertilizer application (T1) and recommended weed control (T2) give intermediate values

and fertility field trials, and the findings were presented each year in July, just before the wet season—so that the recommendations would be fresh in the farmers' minds when they sowed their rice a few weeks later. According to Ibrahim Hann, SAED extension agent for Guédé and neighboring villages, "All of the farmers have now adopted the WARDA/SAED recommendations, and yields are at least one tonne per hectare higher than they were before."

In the Office du Niger on the Niger River inland delta in Mali, the work is at a much earlier stage. However, early results show that there is a deficiency of potassium at this site, so any future recommendation will include potassium fertilizer.

SAED

Malick Sarr, Head of the Planning and Rural Development Department (DPDR) of SAED, is a strong supporter of research and development partnerships. "The work done together by WARDA and SAED is a good example of collaboration between research and development," he explains. "Each year we hold a meeting to discuss our program of activities for the year, how we will work together to complete these tasks, and to evaluate the previous year's results." In March 1999, WARDA and SAED are to hold a meeting with the Institut sénégalais de recherches agricoles (ISRA)—the Senegalese national research institution. Malick Sarr is very positive about this move, "We want to extend the partnership to include ISRA in all our joint activities—research and development must go together!"

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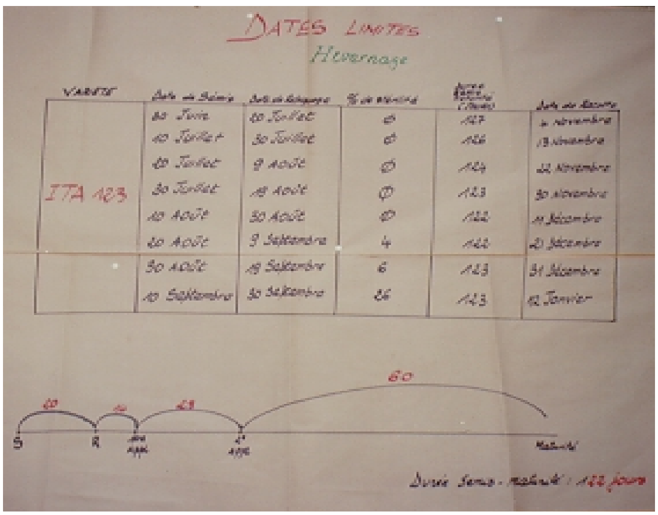


Poster at a farmers' end-of-season meeting showing the effect of sowing date on fertilizer and harvest timing

fertilizer and the market price of the grain, we can then give the farmers a clear indication of their returns to fertilizer use.

The final poster is an overview of the whole season across the irrigation scheme. Here we can point out successes and failures, not in terms of 'good' and 'bad' farming, but in terms of farmers facing few or many constraints (problems) to successful production. This usually opens up into a general discussion on finding solutions to the constraints and improving the farming in general. At the end of the meeting, the recom-mendations for fertilizing next season's crop are presented, and will be presented again by the extension agents before the next crop is grown.

Where are we now?

One over-riding result of this research has been that, in general, applying fertilizer to irrigated rice is a good investment—fertilizer application at an appropriate time is beneficial for the crop, and therefore for the farmer. The three graphs (Figure 2) illustrate the case of Guédé in Senegal. We can see that the variability (among farmers) is large, so there is substantial scope for improvement. Improving nitrogen recovery will increase the benefits (that is, economic returns) from fertilizer use. Furthermore, the risks involved with using nitrogen fertilizer are very low—only about 10% of the farmers surveyed lost money through applying the fertilizer.

Our work in the four countries is at various stages, the work in Burkina Faso being the most advanced. Here we have shown that the current practice of applying a compound fertilizer designed for cotton is inappropriate, and have established new recommend-ations for urea and phosphate (in the form of rock phosphate) in the wet season. The use of compost from rice straw is also recommended. For the dry season, we are advising farmers to apply only a reduced dose of urea, since this is the season most prone to crop failure (due to the scarcity of water and temperature extremes) and therefore the

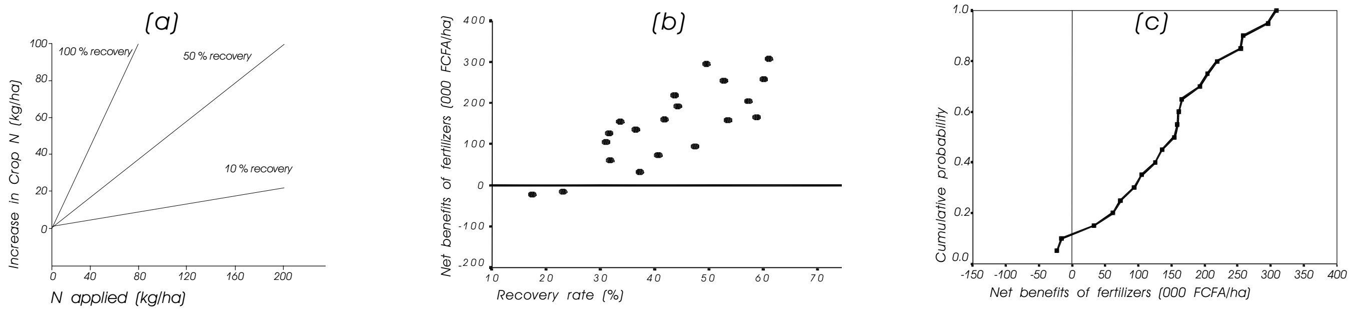


Figure 2. Apparent recovery of fertilizer nitrogen (a), net returns to fertilizer application related to nitrogen recovery rate (b), and probability of benefit to fertilizer application (c) at Guédé, Senegal

AGETA

Sidy Mohamed Ameida, Agricultural Adviser to AGETA, is so happy with the work that WARDA has done with AGETA, that he wants to extend the collaboration. "The farmers we work with fall into three categories based on the size of the irrigation scheme. Each category has different abilities and different expectations. I want us to collaborate with WARDA on evaluating the constraints facing each group, and adapting the latest appropriate technology to these groups. We also need WARDA's input on training." WARDA conducted a general course on rice production for AGETA agents in 1997. "To build on the earlier course," continues Sidy, "we need specific training in fertilizer management, weed control and plant physiology." We see this request as positive feedback on our collaboration to date.

WARDA started working with the Senegalese extension service, Société d'aménagement et d'exploitation des terres du Delta du Fleuve Sénégal et des vallées du Fleuve Sénégal et de la Falémé (SAED) and farmers in Guédé in 1996. Soil fertility has been monitored ever since. In 1997, WARDA/SAED started trials on the application (rate and timing) of urea and diammonium phosphate. The whole scheme of Guédé became involved in the socioeconomic investment may be considered a risk. The fertilizer recommendations are combined with others for sowing dates, age of seedlings for transplanting, and water management in the dry season.

In Mauritania, we have been working with the extension service for 'large' farmers, Association générale des groupements d'exploitants et éleveurs pour l'étude et l'emploi de techniques améliorées agricoles et animales (AGETA) for two seasons. Here, fertilizer recommendations have been combined with weed control recommendations into a package. These combined recommendations increased yields by almost 2 tonnes per hectare over previous cropping practices (see Figure 3). These results are currently being verified in another season of trials.

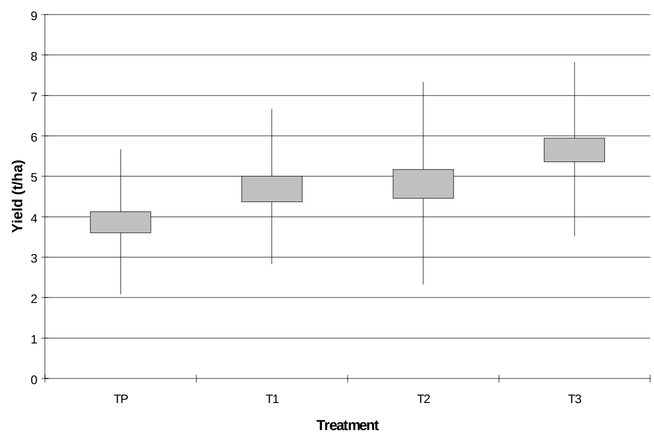


Figure 3. Application of recommended fertilizer and weed-control (T3) gives an average of almost 2 t/ha more grain than the farmers' practice (TP); recommended fertilizer application (T1) and recommended weed control (T2) give intermediate values

and fertility field trials, and the findings were presented each year in July, just before the wet season—so that the recommendations would be fresh in the farmers' minds when they sowed their rice a few weeks later. According to Ibrahim Hann, SAED extension agent for Guédé and neighboring villages, "All of the farmers have now adopted the WARDA/SAED recommendations, and yields are at least one tonne per hectare higher than they were before."

In the Office du Niger on the Niger River inland delta in Mali, the work is at a much earlier stage. However, early results show that there is a deficiency of potassium at this site, so any future recommendation will include potassium fertilizer.

SAED

Malick Sarr, Head of the Planning and Rural Development Department (DPDR) of SAED, is a strong supporter of research and development partnerships. "The work done together by WARDA and SAED is a good example of collaboration between research and development," he explains. "Each year we hold a meeting to discuss our program of activities for the year, how we will work together to complete these tasks, and to evaluate the previous year's results." In March 1999, WARDA and SAED are to hold a meeting with the Institut sénégalais de recherches agricoles (ISRA)—the Senegalese national research institution. Malick Sarr is very positive about this move, "We want to extend the partnership to include ISRA in all our joint activities—research and development must go together!"

Technology Generation and Dissemination: The Role of Agro-ecological Characterization

'AGRO-ECOLOGICAL CHARACTERIZATION' and 'characterization' are terms banded about by agricultural researchers, but what do they really mean, and why is it so important to allocate enough resources to characterization as part of the overall agricultural research program? The Inland Valley Consortium (IVC) is coming to the end of its First Phase and characterization has been a major component of the research program. So the IVC presents the perfect case study.

WARDA has the Consultative Group on International Agricultural Research (CGIAR) ecoregional mandate for inland valley development in Sub-Saharan Africa. The Inland Valley Consortium (IVC) for the sustainable development of inland valley ecosystems is a CGIAR-supported System-wide ecoregional activity convened by WARDA in collaboration with national and international institutions working to improve the productivity and sustainability of inland valley land use systems.

Why characterize?

Farmers' fields are diverse in their characteristics. Compare one field with another and you may well find differences in soil structure, soil nutrient distribution and water dynamics, among other factors. Go to a different scale, and you will find that one farming region differs from another in the same respects, but also in population density, climate, geology, market accessibility and others. Modern agricultural research and development emphasizes the need for technologies (such as crop varieties, farming practices, appropriate machinery) to be specifically adapted to the biophysical environment and to the farmer's needs and resources. How then do we decide what are the most relevant sites for working with farmers to generate technologies and evaluate them, and whether a technology developed for one farm or farming region is suitable for a farmer or farming region elsewhere in the country or even in another country altogether? Trial and error is simply too expensive, time-consuming and wasteful of resources. The answer for saving resources is to work in suitable test sites, which can be identified through characterization—cataloging the characteristics of farm communities and farming regions to determine broad and specific similarities and differences.

The general term characterization is often used for specific descriptions. Agro-ecological characterization is a much broader approach and means a holistic description of agro-ecosystems, including the

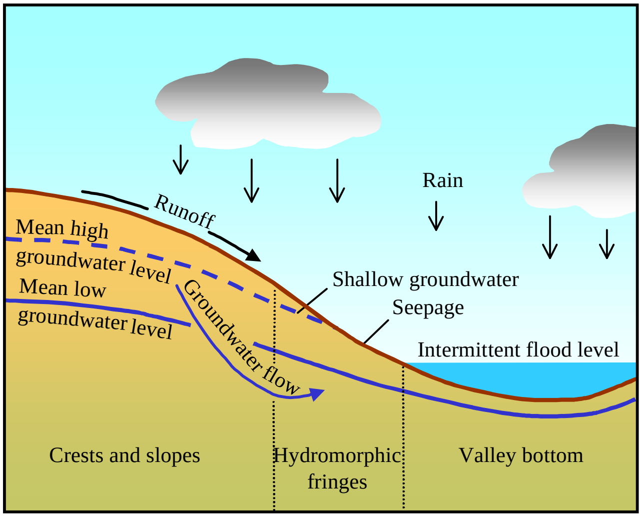


Figure 4. Simplified and stylized cross-section of an inland valley

biophysical and socioeconomic characteristics. The IVC developed a multi-level agro-ecological characterization approach. This approach allows the selection of important and representative sites for technology generation and evaluation, and the quantification of the main constraints to agricultural intensification and diversification. Moreover, the results of the agro-ecological characterization will be the basis for technology transfer. Another application for agro-ecological characterization is as an aid for setting research priorities. As we determine the characteristics of inland valleys and the farming communities within them, we will find some for which there are no technologies currently available. This information feeds back into the research-prioritization process to enable technology-development research to be targeted at the most needy farming systems.

Great potential for food security

The inland valleys are defined as the upper reaches of the drainage systems. Here, the dynamics of the water flowing through the system are quite low, and may be controlled by relatively simple water management systems. Larger floodplains are excluded from the definition. Inland valleys can be divided along the toposequence (cross-section) into three different land units (see Figure 4). The uplands (crests and slopes) are the well-drained higher parts of the system. The valley bottoms are the lower parts, subject to flooding during the rainy season. The hydromorphic fringes are the adjacent strips of land that have a groundwater table near the surface during the rainy season, which is an extra source of water for the crops grown in this zone. Inland valleys present great potential for agricultural expansion and intensification in West Africa, to help feed the fast-growing populations.

The IVC was created in 1993 to explore the potential for intensification and diversification of the valley bottoms and their hydromorphic fringes. It is estimated that there are between 20 million and 50 million hectares of this habitat throughout West Africa (the wide range is explained by the use of different definitions by various institutions and individuals, and the incomplete knowledge of the whole landmass of the region). Of this area, it is again estimated that only 10–25% is under cultivation—hence the scope for expansion. If an extra 2 million hectares of this land were used to cultivate rice alone, at an average yield of 3 tonnes per hectare, the West Africa region could halt the expensive importation of rice from elsewhere! And, this is only looking at the rice crop. Inland valleys present equally great potential for crop diversification, such as vegetables, banana and cassava.

But...

However, just like any other farming ecology, or potential farming ecology, inland valleys are diverse, especially taking into account the hydrology of (that is, water movements within) inland valleys. It is generally understood that the basis for cropping intensification and diversification of the inland valley lowlands starts with improving the water management there. A certain level of water control will allow the introduction of more productive, improved rice cultivation practices. Full water control is not a good option for the inland valleys—because the lowlands cover a limited area, the cost of full water control will never be covered by the increased rice production. A much better option is to go for relatively simple, low-cost water management systems. But, enough information needs to be available to select a good system. Hydrological characteristics depend on more than just rainfall. Other parameters such as lithology (base rock), land use intensity on the adjacent uplands, and morphology play a major role in determining the overall hydrological dynamics of the lowlands. Characterization is the key to understanding the dynamics of the system and identifying technologies developed elsewhere which are, or could be, adopted at or adapted for a particular target site. The more similar the target site to another site where technologies have already been successful, the more likely those technologies will be able to improve farming in the target area. Where appropriate technologies are lacking, the characterization generates all the information required to develop technologies to overcome the prevailing constraints. However, when we decide to characterize even a field there are numerous measurements we could make, both physical—for example, daily temperature regime, water and nutrient flows—and socioeconomic—for example, availability of fertilizers and pesticides, farm income, proximity to market or trade routes. Clearly, to collect all such information would take a very long time, and is totally impractical. From experience, the Consortium identified 'minimum data sets'—see box (page 26)—which should allow sufficient characterization for the purposes of technology generation, evaluation and transfer. But even these are too much for one institution to collect and collate.

Diversification in an inland valley: rice and banana

The approach for agro-ecological characterization

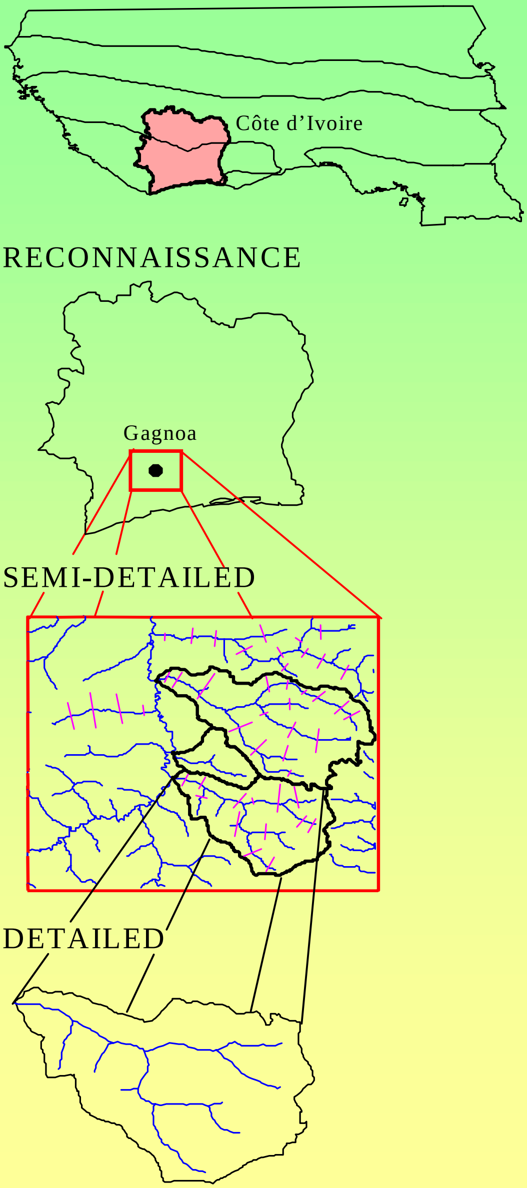
This is where the Consortium concept comes into its own. The Consortium brings together national and international organizations in a research and development partnership that capitalizes on the strengths of each partner and makes the work more efficient (see box, page 28). Even within a partnership, there is still a danger that information collected by the various partners may be incompatible or not comparable. Thus, one of the first tasks of the IVC was to determine standardized methods of data collection to be used by all the partners. In this way, a valley in, say, Nigeria can be directly compared with one in, say, Mali.

"But," you may well ask, "we are talking about at least 20 million hectares. How are we to compare farming communities and valleys over such a wide area?" Of course, we cannot possibly characterize each farming community in every inland valley in West Africa; so, the IVC developed a four-tier system of characterization. **Broad**, or '**macro**,' characterization is done across the whole region; then, '**reconnaissance**' characterization is done at the national level; thirdly, '**semi-detailed**' characterization is conducted for a small region; and, finally, '**detailed**' characterization is done for single inland valley system (see Figure 5, ‘Minimum data sets’ for three levels of agro-ecological characterization as used in Phase I of the IVC

Discipline	Level		
	Reconnaissance	Semi-detailed	Detailed
Agronomy	Main crops; lowland area cropped (%) management; potential	Land use; crop types, associations, rotations; fertilization; crop protection; water inputs; land and water management constraints; mechanization; animal husbandry	*Crops:* variety; cycle; density; planting method; management sequence; associations and rotations; agroforestry; organization and length of fallow; production; yield-limiting factors; *Livestock:* description, watering points
Socioeconomics	Administrative units; ethnic groups; population density and distribution; main activities; infrastructure and markets	Population (demography, gender and ethnic group related activities, migration); infrastructure (markets, roads, schools, health); land and water tenure (access to lowlands, gender, ethnic groups, traditional beliefs); production aims; extension service activities	*Farms:* family size, composition and ethnic group; labor availability; gender and land tenure; distance to fields *Economy:* prices of inputs and outputs; incomes; markets, distance, supplies, input purchase, credit Farmers’ organization; land tenure and water management; subsidies; development agencies; health; education; farmer perception of technologies
Climatology	Rainfall regime; potential evapotranspiration; length of humid period and surplus of water; temporal variability	As Reconnaissance	Daily precipitation data; minimum and maximum temperature; radiation; average wind speed; atmospheric pressure; relative humidity; evapotranspiration; pan evaporation
Geology	Morpho-structural unit (sedimentary basin, basement complex); lithology	Lithology	Lithology
Geomorphology	Land form, slope classes, relief	Description of land sub-elements (slopes, length, width, surface); area of watershed	Land sub-elements and their erosion risks; erosion features and indication of severity; analysis of major erosion-controlling factors
Soils	Major soil units (from national and FAO systems)	Characteristics along toposequence; chemical and physical analysis; degradation; classification (national and FAO)	Standard description to 1.2 m; depth of impermeable layer; general biological activity, condition and degradation risk to top-soil; detailed chemical and physical analysis
Hydrology	Drainage density	Flooding characteristics (frequency, depth, period); stream discharges (if data available); groundwater table fluctuation; water quality; drainage density	*Surface water:* total discharge; base flow; discharge regime; water quality; model rainfall–discharge *Sub-surface water:* fluctuations in groundwater table; sub-surface flow; water quality
Flora	Type of general vegetation; classification	Type of vegetation characterizing different land sub-elements; classification	Vegetation structure, composition, cover (by land sub-element)

Figure 5. The four levels of agro-ecological characterization

Level of characterization	Scale	Geographical coverage
MACRO	1/5,000,000 to 1/1,000,000	Sub-continent, West Africa
RECONNAISSANCE	1/250,000 to 1/100,000	Country e.g. Côte d'Ivoire
SEMI-DETAILED	1/50,000 to 1/25,000	Key area e.g. Gagnoa
DETAILED	1/10,000 to 1/5,000	Watershed/ Village territory



Partners in the Inland Valley Consortium

Countries (partners include NARS, extension services, NGOs and universities)

- Benin
- Burkina Faso
- Cameroon
- Côte d'Ivoire
- Ghana
- Guinea
- Mali
- Nigeria
- Sierra Leone
- Togo

International Institutions

- West Africa Rice Development Association (WARDA/ADRAO)
- Centre de coopération internationale en recherche agronomique pour le développement (CIRAD)
- Food and Agriculture Organization of the United Nations (FAO)
- International Institute of Tropical Agriculture (IITA)
- International Livestock Research Institute (ILRI)
- Winand Staring Centre for Integrated Land, Soil and Water Research (SC-DLO)
- Wageningen Agricultural University (WAU)

Collaborators

- Institut de recherche pour le développement (IRD, formerly ORSTOM)
- Conférence des responsables de la recherche agricole en Afrique de l'Ouest et du Centre (CORAF) networks
- International Water Management Institute (IWMI)
- International Program for Technology Research in Irrigation and Drainage (IPTRID)

Donors

- The Netherlands (DGIS)
- France

page 27). The medium-term plan is to relate the detailed characterization to the other levels and determine which biological, physical or climatic characteristics at the more general levels have the greatest influence on the characteristics of the valleys at detailed level. Once this is done, preliminary targeting of technologies may be done from reconnaissance or semi-detailed characterizations.

The actual approach for agro-ecological characterization is not a final output by itself. After the characterization of 15 key areas in 10 West African countries, we will have a much better understanding of the inland valley systems and the parameters at the different levels which are the main driving characteristics for inland valley properties. The final output of the characterization exercise will be decision tools for technology selection and transfer, with methods for the most efficient collection of the required data. This should represent a major saving in research investment.

The data collected at each level of detail are different, both qualitatively and quantitatively, and so are the tools used to collect them. For **macro characterization**, the major agro-ecological zones of the region are identified on the basis of the length of the crop-growing season. This is combined with other data, such as lithology and morphology, taken from other national and regional studies to define 'agro-ecological units.'

Reconnaissance characterization also depends heavily on information from other sources (for example, maps and reports), but may also involve discussion with extension services on broad agricultural characteristics, and quick field inventories of land use and farming systems. The idea of the reconnaissance characterization is to divide the macro agro-ecological units into agro-ecological sub-units, using parameters which will not change at more detailed levels, such as lithology, rainfall, major cropping system, population density and drainage density.

Semi-detailed characterization is carried out on a 'key area' of 50 × 50 km (2500 km²) representative of a reconnaissance-level agro-ecological sub-unit. Satellite images and aerial photographs are used to identify four watersheds (each comprising at least so-called first-, second- and third-order valleys). Interviews are conducted at each village using the watershed to generate village-level (rather than farm-level) data, and transect (cross-section) studies are made at 8–10 places in the watershed for morphology, soils and land cover. After all these data are processed, one valley system which is most typical for the agro-ecological sub-unit is selected for detailed characterization.

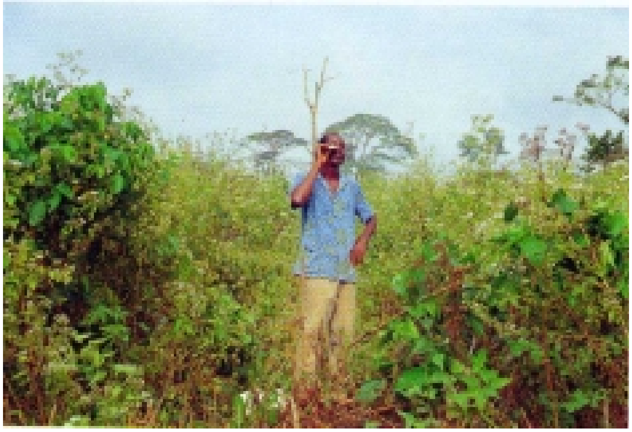
The main objectives of the **detailed characterization** are to understand the functioning of the inland valley agro-ecosystem, to quantify the constraints and production potential, and to assess the variability of characteristics within the inland valley.

In particular, the variability of water availability along the valley affects technology development and evaluation. Detailed characterization involves socioeconomic and agronomic interviews at household and individual level; observations of farming practices; detailed measurement of biological and physical aspects of the farming ecology; detailed measurements of rainfall and water movements; and surveys of soils and land use.

It is this detailed characterization that enables us to identify the farm-level problems in the farming systems, and it is mostly these problems that have to be addressed by the technologies developed by agricultural research. Thus, if we can find links between characteristics at the reconnaissance and semi-detailed levels of characterization which can be used to predict the characteristics at the detailed level, and therefore the problems facing farmers in a particular system, we should be able to identify technologies which have good potential for adaptation and adoption in the target watershed. Where these technologies do not exist, the same approach gives feedback to research on technologies to be developed.

The agro-ecological characterization approach has elements of known research procedures. Agro-ecological characterization through biological and physical measurements such as climate, soil, and seasonal changes in water availability is standard methodology. So too, are the socioeconomic studies used in this work, although these are much more difficult to quantify. What is novel about the IVC approach is the combination of biophysical and socioeconomic characterization at different levels of scale. A second novelty in our approach is that all the stakeholders (scientists, farmers, extension officers, etc.) are working together in the key sites on constraint analysis and selection of technologies to be evaluated or to be generated.

Interviewing farmers for general information on cropping practices for semi-detailed characterization



Measuring the direction of a transect for semi-detailed characterization

Although Phase I is almost complete and not all the characterization has been done, it cannot be assumed that implementation of the approach takes five years. Considerable time was allocated in the first two years to developing the common methodology, and bringing together and organizing the different stakeholders in the IVC member countries. In addition, the macro and reconnaissance characterization are only conducted once. In new key sites only the semi-detailed and

Outputs from the IVC Phase I

Basic outputs

Much progress was made in the characterization exercise during the First Phase of the IVC (see map opposite). In a few countries, the agro-ecological characterization is yet to be finalized. This is due in part to the time that some countries became members of the IVC—this is the case for Guinea (1996), and Cameroon and Togo (1998).

Strategic outputs

In addition to the standard agro-ecological characterization, several countries carried out supplementary activities.

- The role of women (farmers) in the inland valleys (Benin and Ghana).
- A methodology to use satellite images at the semi-detailed level was developed (IITA).
- The potential for using the natural vegetation to characterize the extent of the hydromorphic zones (WAU).
- A set of socioeconomic indicators was devised for semi-detailed characterization (WARDA).
- All of the characterization data from Benin was uploaded to a comprehensive database (Benin).
- Much of the characterization data collected by the IVC partners was consolidated into a geographical information system (GIS) (IVC Regional Coordination Unit).
- A rapid appraisal to characterize the inland valley hydrology and a decision support system for the selection of the most appropriate water management technology in that valley were developed (CIRAD, Mali and Ghana).

Applied/adaptive outputs

Member countries that completed the characterization exercise proceeded with a plan of inland valley lowland development with active farmer participation. Two examples are given here.

Benin

In the Gankpétin key site, simple contour bunds were constructed by the farmers to improve water distribution in the slightly concave valley bottom. This resulted in considerable pay-offs:

- the cultivation of maize as a pre-rice (pre-flooding) crop was improved (in cooperation with IITA);
- rice production in the main season, when flooding occurs, has been increased by the introduction of improved varieties, modified planting density to combat weeds, and better use of fertilizers;
- post-rice cultivation of vegetables profits from the increased availability of residual water, due to the increased storage of water by the introduced water management system.

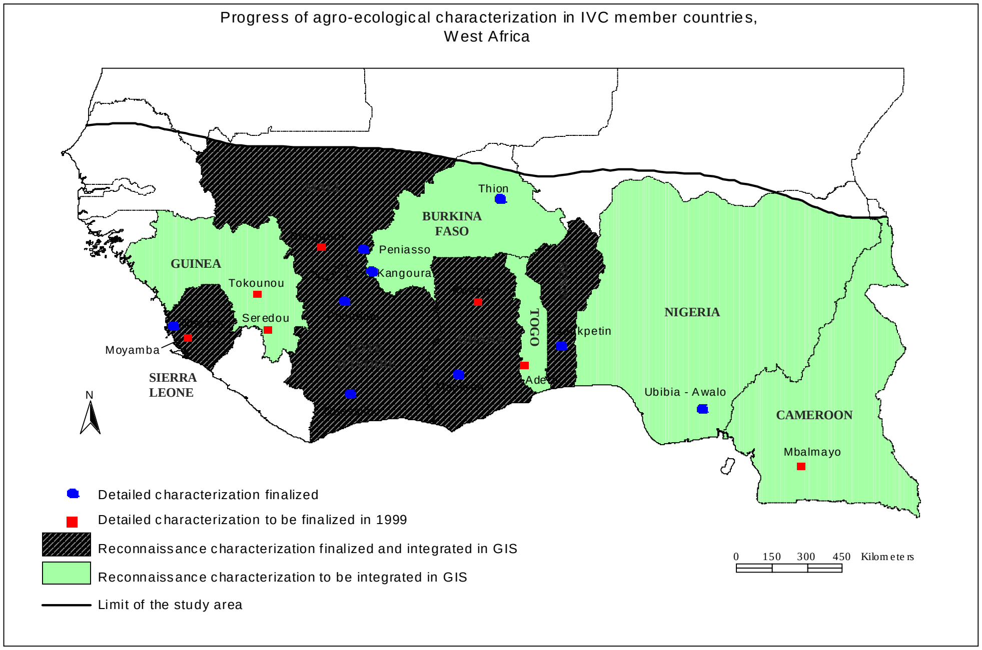
The introduced technology packages are so successful that farmers are spontaneously developing inland valley lowlands downstream of the project site.

Ghana

In the Mankran key site, rice alone is cultivated in the narrow and flat valley bottom. The rice fields were bunded, and a central canal constructed (for irrigation and drainage).

- The improved water management allowed the introduction of improved varieties and cropping techniques, including transplanting in rows, and the use chemical and organic fertilizers.
- Because this site is situated near Kumasi, farmers are producing rice for market (rather than for home consumption), and are able to invest more in fertilizers and other inputs.

detailed characterizations have to be implemented. The ‘minimum data sets’ collected in Phase I are now available for assessment. We will use this to identify the essential data sets for future characterization, which will consequently be smaller and therefore easier to collect. This will include identifying the most efficient ways of sampling the defined parameters; for example, it may be determined that a critically timed measurement of water flow once per year can be used instead of monitoring throughout the year—we aim to develop such rapid appraisals to replace detailed measurements. With the refined minimum data sets and the rapid appraisals, full characterization can be implemented in 1 to 2 years.



Phase II—1999 and beyond

In 1999, most of the countries will start developing the lowlands of their key sites and evaluating improved production technologies. Where the technologies are adopted and adapted by the farmers in the key sites, the national extension services will be able to transfer the technologies to other farmers in the different regions.

In the second phase of IVC, starting in 1999, more emphasis will be put on technology evaluation and transfer. Apart from finalizing on-going characterization activities, some new characterization activities will be initiated. These will focus on quantification of the dynamic processes in inland valleys, including hydrology and nutrient fluxes, and the impact of land use changes on these dynamic processes. The results of this characterization will be used to estimate the impact of improved technologies on the natural-resource base, in other words, the sustainability of the newly introduced technologies.

Maintaining an irrigation canal—an essential activity for sustainable rice farming

Allies in the War on Weeds

WEEDS ARE recognized by farmers and researchers alike as the largest single cause of yield loss in rice, and the largest consumer of labor. In the early 1990s, WARDA teamed up with the Natural Resources Institute in the UK to start a major offensive against rice weeds. The result is that we are now much better prepared for the war, and our armament is increasing all the time. We will never see the end of weeds, and probably shouldn't want to, but we can certainly aim to maximize returns to farmers' investments in rice production!

WARDA has a mandate for rice research in West Africa; the Natural Resources Institute (NRI) has many years experience in managing crop pests, including weeds. Weeds are the major pest of rice in West Africa; so what better combination to tackle the problem in West Africa than WARDA and NRI? This is exactly what the two institutes decided in the early 1990s. After preliminary discussions, a project proposal was designed for consideration by the UK Department for International Development (DFID, then the Overseas Development Administration or ODA)—the upshot was that an NRI Weed Scientist, David Johnson, was stationed at WARDA's headquarters to coordinate the joint research efforts, and to conduct many of them.

From the beginning, weed research activities were integrated into WARDA's multi-disciplinary teams, while at the same time WARDA agronomists, economists, entomologists, breeders and pathologists were drawn into the WARDA/NRI weed activities. The use of multi-disciplinary teams is essential for achieving a holistic view of a problem—intervention in one area so often has a knock-on effect to another area. Maximizing crop production, be it in terms of output or efficiency, depends largely on finding the right balance of crop and other resources management and interventions to get the best out of the crop and the resources used in growing it.

What the farmers think

By the early 1990s, WARDA and NRI realized that improvements in crop production were only likely to be of value when they are designed specifically to deal with farmers' problems as farmers see them. So, along with early research into weed distribution and their impact on the crop, a survey was conducted among 178 rice farmers to see exactly how they perceived the role of various pests in their crop. Every single farmer identified weeds as a problem! This compares with 84% citing birds, and a mere 40% recognizing the importance of insects (see Table 2). It seems that visibility of the pest plays a role in farmer perception, but this does not detract from the importance of weeds.

Studies on the effects of weeds soon showed that the farmers' perception of this pest is correct: in three of the main rice-growing ecologies of West Africa—rain-fed upland and hydromorphic, and direct-seeded

Weeding consumes more labor than any other single task

(as opposed to transplanted) irrigated systems—weeds are the main yield-limiting factor, reducing production by 25–30%, and sometimes up to 40%. In fact, if weeds were left uncontrolled, total crop failure could ensue. It is not surprising, therefore, that farmers invest more labor in weed control than in any other single farm activity for their rice crop. Tim Dalton, WARDA production economist, reports "between 27 and 37% of the total labor invested in rice is taken up by weeding. Since farming in West Africais essentially limited by the availability of labor, rather than the availability of land, any reduction in the labor required for weeding would free farmers to expand their cultivation and therefore grow more rice." In this way, it is weeds that keep small farmers small.

To make matters worse, farmers in the survey indicated that intensification of rice cultivation (that is, growing rice on the same piece of land more often) was making the weed problem worse. Traditionally, farmers have practised slash-and-burn agriculture, with land left fallow between farming cycles for eight or more years (especially in the forest). The increasing need to produce more food (partly as a result of population growth) from the same land has led to a serious reduction in fallow periods and a simultaneous increase in the number of years a piece of land is farmed before being abandoned to fallow.

To quantify this, trials were conducted on farmers' fields in the forest, transition and savanna zones in which farmers' intensive (short fallow) or extensive (traditional fallow) cropping were compared. This study showed that, across the agro-ecological zones from forest to savanna, intensification of rice farming led to

Table 2. Percentage of farmers citing various pests as problems in rice production, Côte d'Ivoire, 1992

Pest	Agro-ecological zone			
	Humid forest	Forest–savanna	Savanna	Combined
Weeds	100	100	100	100
Birds	98	98	53	84
Rodents	88	87	2	60
Insects	48	60	12	40
Diseases	23	3	0	9

Sixty farmers were sampled in each of Gagnoa (humid forest) and Touba (forest–savanna), and 58 in Boundiali (savanna).

Traditional practice is to slash-and-burn the natural vegetation after at least eight years of fallow—the long fallow and burning reduce the number of annual weed seeds in the soil

As production is intensified, fallows become shorter and each piece of land is cropped for more seasons in a row. The result: increased weed problems, seen here infesting the young crop

a 38% reduction in yield, and that 54% of this reduction was attributable to weeds. The weed growth itself was 75% greater on the short-fallow fields than on the long-fallow ones.

So, the stage was set for the development of techniques for reducing weed pressure on rice. Weeds had clearly been identified as a major constraint in rice cultivation, and as farming becomes more intensive, the problem is getting worse. At this point, we have to bear in mind that we are dealing with poor farmers—farmers who have little access to chemical pesticides or fertilizers. So, control with, or at least total reliance on, herbicides is not an option.

Into battle

Two avenues of research in particular have proved fruitful: first, the use of rice plant types that are inherently more able to suppress weeds than others, and second the use of legume crops during the 'fallow' part of a crop rotation.

Research at WARDA to identify rice varieties which can compete successfully with weeds began in 1992 with the screening of a range of varieties grown under low-input conditions. The varieties expressed clear differences in weed competitiveness. An early finding which has been borne out by later studies was that weed suppression can be a direct result of profuse early growth—in particular, some examples of the cultivated African rice (*Oryza glaberrima*) out-compete weeds very successfully. The advantages of *O. glaberrima* in weed-suppression are a result of the way the plants develop with vigorous early growth, and droopy leaves, which form a canopy under which weeds cannot thrive. *Oryza glaberrima*, however, has low yield potential, so was only really beneficial under high weed pressure, when the higher-yielding but weed-susceptible varieties were smothered. The major breakthrough, by Monty Jones at WARDA, of producing fertile offspring of crosses between *O. glaberrima* and high yield-potential Asian rice (*O. sativa*) opened the door to capitalizing on the weed-suppressing features of *O. glaberrima*. The story of 'new rice for Africa' should be well known to most readers of WARDA's Annual Reports—plants have been produced combining the early weed-suppressing characteristics of the African parent with the high yield-potential of the Asian parent.

Comparison of weed-competitive variety (background) with traditional variety (foreground) at early vegetative stage—the profuse growth and droopy leaves seriously hinder weed growth

NRI/WARDA screening methodology for weed competitiveness, using an African rice (*O. glaberrima*) as the experimental 'weed'

As a result of WARDA's emphasis on weed competitiveness, screening methods are being developed whereby many lines can be assessed at one time for their likely productivity in competition with weeds. Results to date suggest that maize and IG10 (a competitive *O. glaberrima* rice) are effective competitors and, therefore, good experimental 'weeds.' Each line to be screened is grown in a single row bordered by 'weed' rows. Two indicators for weed competitiveness have been determined: 'specific leaf area,' that is leaf surface area per unit weight of leaf, and the early growth of tillers. Such methods will enable a large number of lines to be screened, and the promising ones to be put into full field screening, yield trials and later on-farm trials.

Working with Mathias Becker, the WARDA agronomist, the WARDA/NRI project investigated the use of legumes in place of traditional (weedy) fallows. The idea is that the legumes smother weeds, limit soil-erosion, and increase the organic matter and nitrogen contents of the soil. Some 39 legume species were tested in comparison with weedy fallow. Rice was grown immediately after harvesting of the legume or clearing of the fallow. The theory was upheld, with some legumes substantially increasing soil nitrogen and decreasing weeds in the subsequent rice crop (see Figure 6), and consequently supporting greater rice yields. In terms of weed control, a suitable legume reduces the build-up of crop weeds during the fallow period, thus reducing the number of seeds waiting to germinate in the soil when the rice is grown. The work also investigated the performance of various legumes in the different ecosystems, leading to the identification of suitable legumes for each farming system.

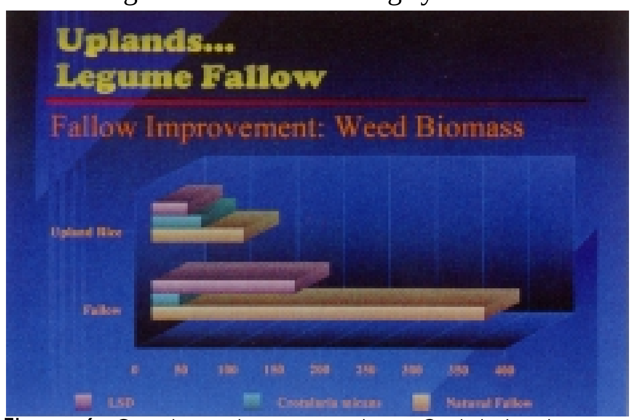


Figure 6. Growing a legume such as *Crotalaria nicans* during the fallow period reduces the weed biomass in the subsequent rice crop

The effect of 'legume fallows' on rice production is not a simple matter of weed suppression; in fact, the increase in soil nitrogen as a direct effect of growing the legumes is probably more significant in improving rice yield. This is an illustration of the different levels at which various interventions work—hence the collaboration between weed science and agronomy.

Thus, we have two major interventions applicable at farm level. Firstly the use of weed-competitive rice varieties, and secondly the introduction of legumes into the fallow part of the crop rotation. Both methods help reduce the weed problem in the rice crop, thereby reducing the amount of time that farmers have to devote to weeding. This in turn opens up the possibility of expansion of the rice area and small farmers may, in future, not be so small!

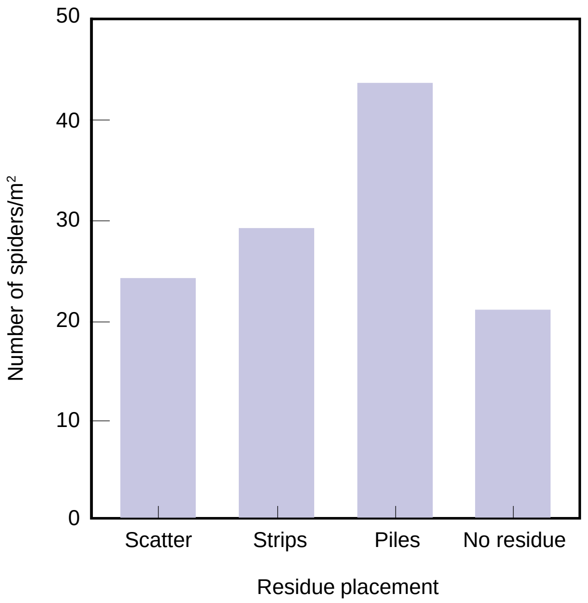
Legumes, such as this *Lecuna*, used as cover crops in place of natural fallow, increase soil fertility and decrease the incidence of weeds in the subsequent rice crop

Weeds as allies

The rice field is a dynamic ecosystem and controlling weeds may affect other components of the pest complex. In particular, it was considered worthwhile to investigate the effects of weed management on insect pests (another cause of serious yield loss in rice) and their natural enemies (mainly predators). Research student Kofi Afun undertook three years of study on this aspect with the weed project, through which he not only gained his PhD, but also a national prize for research from his home country, Ghana. The main predators of insect pests in rice are spiders and predaceous insects (mainly beetles and dragonflies). Any amount of weeding significantly reduced the spider populations in the rice fields, but leaving the crop unweeded simply led to total crop loss through weed competition. Spider populations were higher in manually weeded fields than in herbicide-treated fields. Conversely, populations of rice insect pests were unaffected by weed control methods—that is, there were as many rice insect pests in herbicide-treated and hand-weeded plots as there were in unweeded plots.

Experiments on the management of weed residues (i.e. what is done with the uprooted weeds) showed that placing the uprooted weeds in piles within the rice field resulted in significantly larger populations of spiders than did scattering, laying in strips or removing the weed residues (see Figure 7). For timing of weeding activities,

Figure 7. Effect of weed residue management on spider populations



mid-season weeding resulted in the most active spider populations. In fact, mid-season hand-weeding gave similar rice yields to herbicide-treatment, without depleting the spider population. Further studies are underway to determine the extent of interactions between weeds, insect pests and the latter's natural enemies.

Another problem altogether

So far, we have talked about weeds as competitors for resources (soil, light, water), but there is another group of weeds which has also been the subject of research by the WARDA/NRI project—parasitic weeds. The parasitic weed *Striga* doesn't so much compete with the rice crop for nutrients, as steal those nutrients from the rice plants themselves! What is more, parasitic weeds like *Striga* are among the most prolific seed producers in the plant kingdom. One plant can produce more than 100 thousand minute seeds—enough to infest surrounding fields over a large area! While *Striga* in Africa is principally a problem on maize, sorghum and millet, rice can be devasted where the soil is infested with *Striga*.

Research on *Striga* started with a series of experiments in the UK. A wide range of rice varieties was screened by another NRI weed scientist, Charlie Riches, for resistance to *Striga* in a greenhouse at Long Ashton Research Station (home of NRI's weed research group). Seeds of two species of *Striga* known to parasitize rice—*S. aspera* and *S. hermonthica*—were collected from Côte d'Ivoire and elsewhere in Africa for use in the screening. The varieties which showed resistance in the UK were then tested in field trials in natural *Striga* 'hot spots' in northern Côte d'Ivoire (*Striga* is restricted to the savanna, and is not found in the forest zone). Varieties of *O. sativa* and *O. glaberrima* were resistant to *Striga* in the greenhouse (that is, they were attacked infrequently), but much of this resistance was not evident in the field in Côte d'Ivoire. Overall, however, *O. glaberrima* had fewer *Striga* plants growing on it and was more tolerant of the *Striga* than *O. sativa* was (that is, the rice plants did 'well' *despite* infestation by *Striga*). Such differences indicate that resistance and tolerance are available in rice for utilization in breeding programs. Crosses made on the basis of these field trials are now being tested in greenhouses in the UK.

Striga hermonthica parasitizing rice: this plant sucks nutrients from the rice plant itself, and then produces hundreds of thousands of seeds!

Widening the network of collaboration

The latest avenue of the WARDA/NRI weed research program greatly broadens the research partnership to include the Centre for Arid Zone Studies of the University of Wales (UK), the International Rice Research Institute (IRRI, Los Baños, The Philippines) and the Agronomy Institute, Harare (Zimbabwe).

The work on weed-suppression showed the importance of rapid rice plant development to shade out weed seedlings. Thus, any means of speeding up the early development of the rice plant should give the crop an advantage over weeds. Such a method is 'seed priming'—soaking seeds in water and then drying them before sowing. The method was developed by seed companies in temperate zones for the advantage it gives the seed at the time of sowing—the seed is 'primed' to germinate by the pre-soaking, so utilizes water available in the soil at sowing to germinate, whereas germination is delayed in un-primed seeds. The method has already been applied successfully by the Centre for Arid Zone Studies in trials in India, where primed seed led to plants which not only germinated faster than un-primed ones, but also developed and matured faster—a goal in itself for the Indian farmer.

The advantages bestowed by seed priming of rice, especially in terms of weed suppression, are to be tested and are expected to be significant. The method is already adapted to the farm level through the work in India: farmers can soak their own seeds over night, then surface dry and sow them the following day. Once dried, the primed seeds should retain their advantage over un-primed seeds for several days; so a short delay in planting should not negate the value of priming.

Concurrent with on-station trials into the effects of seed priming on rice development, seed priming will be introduced into WARDA's Participatory Varietal Selection program to evaluate farmers' perception of the method. Meanwhile, the reaction of different varieties will be assessed in trials at Bangor and IRRI.

To further develop collaborative links, WARDA is a member of the project on Integrated Weed Management in Rice (part of the CGIAR System-wide Program on Integrated Pest Management). This project has the objective of fostering collaboration among research groups in Africa, Asia and Latin America, together with advanced institutions, so that greater progress and impact can be made in reducing the high costs and drudgery involved in weed control world-wide.

The collaboration between WARDA and NRI has yielded a lot of information on the dynamics of weeds in rice fields. It has also brought out several useful interventions that farmers can apply to manage weeds to improve their rice yields, while highlighting the negative effects of completely destroying and removing weeds from the field. That collaboration has now spread out to encompass three more research institutions, so the benefits of this collaboration are being shared for the benefit of rice farmers throughout Africa and Asia.

Farmers Producing Seed for Farmers

SEED PRODUCTION and distribution are notorious bottlenecks to the dissemination of new crop varieties. National seed systems are all too often under-resourced in terms of staff, equipment and funding, and therefore unable to meet production needs. Côte d'Ivoire, with help from WARDA, is putting farmers in a position to do the job themselves.

It is very frustrating for crop breeders to see the results of many years' work take so long to reach the farmers. It can take up to 10 years for a breeder to develop an improved variety, but it may then take another seven years after release by the national program for enough seed to be produced so that farmers can grow it! And this is not just a problem for rice—it is a well-known phenomenon in countries where the seed service is in the public sector.

This was exactly the problem in Senegal some years ago, so the Institut sénégalais de recherches agricoles (ISRA) set about finding a solution to the problem. Dr Amadou Moustapha Bèye has developed an open system whereby farmers are encouraged to take a small quantity of seed and to multiply it for themselves and their neighbors, which he details in a booklet, *Training Manual on Standards and Techniques of Rice Seed Production*. In May 1998, when he joined WARDA as a Visiting Scientist, he proposed to promote farmer seed production throughout the West Africa region, and especially in Côte d'Ivoire. Here, the rate of certified seed utilization is low and is restricted to irrigated zones, where conventional seed multiplication is implemented.

The problem

The national seed system is market-oriented and is based on the production of certified seeds to European standards, while the majority of farmers regularly use farm-saved seeds of local varieties. For some years now, the use of improved varieties has been decreasing. The reasons for this are many, including the following:

- lack of Certified seeds of improved varieties
- weak system of variety release and registration
- high costs of inputs
- lack of, or non-functional, seed quality control system
- limited role of the private sector in seed production
- limited supply of Breeder seeds.

The conventional (or 'formal') system for seed multiplication current in Côte d'Ivoire is typical of many developing countries (see Figure 8). Once a variety has been released, the breeder provides 'Breeder' seeds from which three classes of seeds are maintained:

- Foundation or Basic seed (G0, G1 and G2)
- Registered seed (G3)
- Certified seed (R1 and R2).

The seed system is organized by the Sous-Direction des semences et plants of the Ministry of Agriculture. The Laboratoire national d'appui au développement agricole (LANADA) controls each variety's genetic identity and purity during the whole process of seed multiplication. The extension agencies, Projet national riz (PNR) and Agence nationale d'appui au développement rural (ANADER), are responsible for the seed production and distribution to farmers. The system requires about six years from release of a variety to produce sufficient seed for distribution to a large number of farmers. Usually, it's only in the seventh year that any farmer who needs seeds can actually buy them!

The solution

In response to the decline in the use of improved rice varieties, the Ivorian Ministry of Agriculture initiated a special seed revival program in 1998. The program is aiming to change the seed capital in one year for irrigated rice and two years for rainfed rice.

A new scheme of seed production, based on an optimization of farmers' practices and indigenous knowledge, has been proposed as an alternative seed supply mechanism for small-holder farmers (Figure 9). This is being implemented on a trial basis by WARDA with the collaboration of ANADER and Projet BAD-Ouest (a project in western Côte d'Ivoire, financed by the African Development Bank).

Figure 8. Conventional scheme

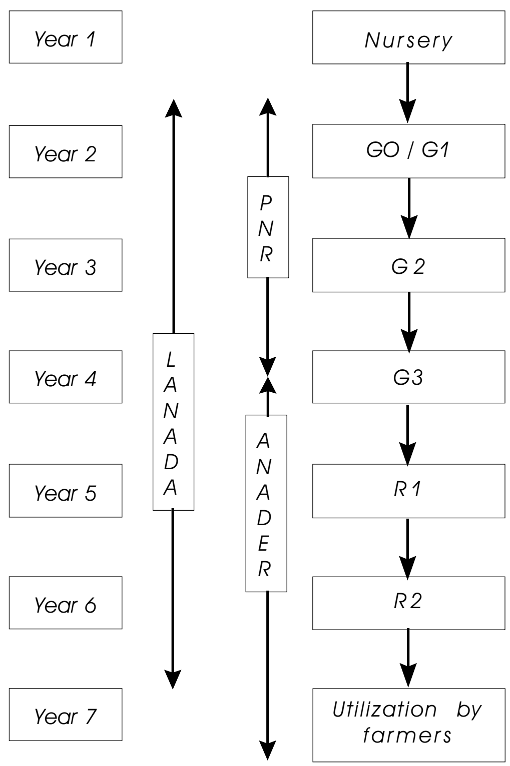
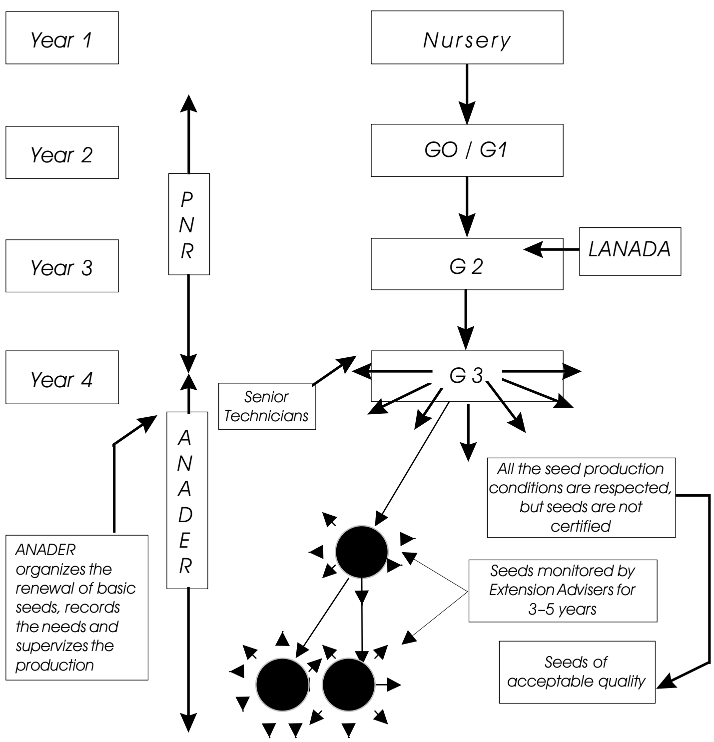


Figure 9. Community-based seed production scheme



Yeo Zana produced 3 tonnes of seed of 'acceptable quality' at Niofouin in the forest zone

What farmers must do to maintain seed quality

Successful application of this model of community-based seed multiplication is not simply a matter of handing over a few seeds to a few farmers, however select they may be. First, farmers must be willing to produce their own seeds. Those that are willing receive advice on:

- purification of seed, by the removal of 'off-types' (that is grains which do not conform to the standards of the variety);
- choosing the best panicles (the plant heads bearing the seeds) before harvesting for food;
- careful handling of seeds during harvesting, threshing, winnowing and storing;
- proper drying of seed;
- germination testing of seed.

It targets subsistence agriculture farmers, who produce about 90% of the national rice production.

A major premise of the new system is that farmers should be able to use seed of 'acceptable quality,' rather than having officially Certified seed. In this system (Figure 9), LANADA certifies only the Foundation seed (G2). The extension services (ANADER and PNR) make small quantities of this seed available to various 'informal' seed-multipliers—for example, farmers' cooperatives, entrepreneurial seed-producers, non-governmental organizations. These will then produce seeds for their communities by using their usual practices. In this way, seed can be provided to (at least some) farmers within four years of variety release—three years earlier than under the purely 'formal' system. At the same time, national seed service resources are not overstretched trying to meet the whole country's seed requirements.

The seed production and distribution is done according to farmers' practices and capabilities. Some simple guidance is given to help farmers maintain the seed purity during a period of 3 to 5 years (see box).

Rice is a self-pollinated crop, which means that the vast majority of the seeds harvested are genetically the same as those sown, so farmers do not have to replace their seed stocks every season. The major concerns of deterioration of seed quality over time—that is, reduced germination ability and purity—are monitored at the farm level by the extension services.

Does it work?

The model has been successfully tested in 1998 in collaboration with ANADER in five localities—Man, Danané, Odienné, Korhogo and Boundiali—where several on-field workshops were organized with farmers. Discussions were held on seed purification, drying, germination testing, storage, and the conservation of landraces.

With sponsorship from the BAD-Ouest Project, two seed production booklets have been written, one for farmers with limited education and the other for the ANADER extension agents who work directly with the farmers. These booklets are being prepared for use in the next farmers' and extension workers' training sessions to be held within the region.

From 26 to 31 October 1998, a training workshop entitled *Improvement of Farmer-saved Seed: A New Approach for Sustainable Subsistence Agriculture* was held in Man (western Côte d'Ivoire). The meeting brought together WARDA researchers, officials from the target region and organizing institutions, ANADER and BAD-Ouest Project extension agents and farmers, to discuss on how to ensure a better application of the model in Côte d'Ivoire.

Farmers who participated in the meeting, especially women, displayed a good knowledge of on-farm seed production, proving that seed multiplication based on local practices and indigenous knowledge is a viable option. At the end of the workshop, the Head of the Seed Production Service of ANADER decided to adopt and implement the model (as a complement to the formal system) as soon as possible, and has asked WARDA to provide technical assistance by training their technicians in the necessary techniques (on-farm monitoring and training of farmers).

Training constitutes a major activity of the model. It has three components. First, field-workshops, in which farmers share experience and discuss progress with extension agents and researchers on how to improve the seed quality at farm level. Two or three such workshops are organized during the rainy season.

Second, a training session which focuses on:

- how to organize harvesting and postharvest activities better
- how to set-up a network at the village level
- the maintenance of variety purity
- the maintenance of seed germination ability
- seed testing.

Finally, an awareness and evaluation workshop at the end of the season, which discusses:

- seed distribution at the village level
- evaluation of the impact of the seed system at the regional level
- assessment of farmers' needs for the next season.

Through the training, farmers are encouraged to store every year about 50 kg of seeds of acceptable quality of improved, as well as traditional, varieties. Training is also a good opportunity to teach technicians on how to optimize farmers' practices and indigenous knowledge in seed production.

Training workshop in Man (Côte d'Ivoire): diplomas were presented to the farmers by the Mayor of Man, and ANADER and BAD-Ouest officials

Traditional seed storage in the savanna (above) and humid forest (right) zones: these systems are well adapted to farmers' realities

The results are exciting. A recent case study in Korhogo showed that many farmers involved in the farmer-saved seed program have established their own reserves. For example, in N'Ganon and Niofouin, the farmers' groups have delivered to their respective 'Village Unions,' 2 tonnes of seeds of each of WITA 1 and WITA 3, and 2.5 tonnes of WAB 56-50. These seeds will be disseminated throughout the villages in the Prefectures of Niofouin and Sirasso. Support has been also given to farmers who have requested seed of newly released varieties (Table 3).


For farmers to become seed producers, they need merely select the best panicles at harvest time and harvest them separately

Table 3. Recently released rice varieties distributed to farmer seed producers in Côte d'Ivoire

Region	No. locations	Varieties†
Danané	14	WITA 1, WITA 3, WITA 7, WITA 9
Man	50	WAB 56-50, WAB 56-125, WAB 96-1-1, WITA 1, WITA 3, WITA 9
Korhogo	20	WAB 56-50, WAB 96-1-1, WAB 56-125, WAB C 165, WITA 1, WITA 3, Bouaké 189
Boundiali	5	WAB 56-50, WAB 56-125, WAB C 165

† Bouaké 189 is an Indonesian variety introduced through an IRRI international nursery; WAB 56-50, WAB 56-125, WAB 96-1-1 are WARDA upland varieties; WAB C 165 is an upland variety introduced from Brazil; WITAs are WARDA/IITA lowland varieties—1, 3 and 7 are for irrigated or rainfed farming, 9 is for irrigated only.

The benefits

The model is simple to run, because it can be merely a matter of selecting the best panicles—to be used for seed, rather than grain (food)—at harvest time. Thus, seed 'production' begins at the on-set of the harvesting campaign, whereas the conventional model runs from before sowing when the producer has to declare an intention to produce seeds.

The model has several advantages over the conventional system.

- It is an open system, utilizing the farmers' cultural practices and their channels for seed distribution, and it encourages the full promotion of traditional varieties. The conventional system is 'top-down,' with complete control by the seed authorities.
- It reduces the seed production costs, which are similar to the costs of producing paddy.
- It reduces the time for a newly released variety to reach to the farmers, from 7 to 4 years.
- It helps any farmer who is interested to produce seeds with 'acceptable quality.'
- It facilitates the rapid dissemination of improved varieties and incorporates traditional varieties into an official seed system.
- It encourages the availability of seeds of 'acceptable quality' at the village level and a consequent improvement in production.

This new scheme offers a further avenue for the dissemination of the interspecific progenies (*Oryza sativa* × *O. glaberrima*) into the agricultural subsistence system; helps farmers to become more self-sufficient in seeds, and helps them to better handle local indigenous diversity. With the high level of adoption of the interspecific progenies in Côte d'Ivoire, Ghana, Guinea, Nigeria and Togo, farmers will need a better targeted approach to help them ensure good maintenance of, as well as access to, seeds of improved varieties as well as from traditional ones. This model is one such approach.

Linking African Scientists to the Information Highway

THE ELECTRONIC era has changed the way many people in the world view information. Many countries in West and Central Africa had communication problems even when science was communicated in print, now national scientists may be forgiven for feeling even further left behind. WARDA is rectifying that by connecting national agricultural research institutions to the Internet and bringing their scientists into the information age.

As we approach the turn of the millennium, it seems that the gap between the 'haves' and the 'have nots' is growing wider rather than narrower. Computer technology, especially the global network known as the Internet, has revolutionized communications and information sharing, to the extent that the average school child in the 'north' or 'west' today would be lost if placed in a school with the facilities of, say, 15 years ago. But the multiplication of information technology has not been at an even rate on a global scale. In particular, the poor telecommunications facilities in many West and Central African countries, exacerbated by their general financial status, have severely hindered their ability to hook in to the information age.

The value of agricultural research is seriously limited if that information is not distributed to potential users. In the past, many national agricultural research systems (NARS) did not have access to up-to-date and relevant research information. In addition, much of the work conducted by the NARS researchers was lost, as they had no way to disseminate the information to their peers in other countries, and even had problems getting the results to their own farmers. These communication problems were (and in many places continue to be) complex, resulting from poor 'public' communications networks and poorly developed information infrastructure within the NARS themselves. Indeed, the latter was often a result of the former. With erratic and unreliable international (and national) postal systems, it is difficult for researchers and libraries to obtain the publications they need to keep abreast of new findings. Without access to bibliographic databases, researchers do not even know what other research is going on around the world! Without good communications, scientists do not know where to publish their results so that others may read them—and, even if they do, there is no guarantee that the results will be efficiently recirculated within their own region.

Information networking

The CGIAR approach of initiating networks like the WARDA Task Forces (see page 9) provides a way of sharing information on a wider scale. However, traditional travel for meetings and print publishing are both costly and time-consuming. The Internet provides a means of rapid communication at relatively low cost. With funding from USAID, WARDA initiated the AfricaLink project in 1997 to give NARS and extension services access to the Internet, to improve their abilities to access and distribute information, and to communicate with their peers world-wide.

"In collaboration with the Conférence des responsables de la recherche agricole en Afrique de l'Ouest et du Centre (CORAF), we dispatched letters and faxes to more than 80 heads of research and extension institutions, network coordinators and agricultural scientists throughout the region in October 1996," explains project coordinator and WARDA documentalist Alassane Diallo. "We also advertised the project through various regional meetings in late 1996 and in 1997. As a result, we received responses from 51 institutions." These institutions requested WARDA to connect some 142 sites to provide electronic-mail access to between 1000 and 1500 research scientists. By the end of 1998, funds had been allocated to connect 91 of these sites.

"AfricaLink is more of a capital grant than operational funding," explains Diallo, "with the addition of installation and on-site training." The project pays for the hardware—usually just a modem—to establish the connection. But, if the site doesn't have a computer with enough capacity to handle the connection, then the project will even supply the computer. Project staff then install the hardware and software, and configure the system to operate through the local Internet provider. The project also pays the subscription fees and a lump sum to cover the initial period of connection (one month, semester, quarter or year, depending on the provider). After this, the recipient institution is expected to carry the expense of continued connection and use of the facility. In fact, commitment to continue the service after project funds are used up is a prerequisite to the allocation of the funds.

AfricaLink staff from WARDA or USAID follow up the installation with site visits to verify the smooth running of the system, and to provide training for at least two users.

Spreading the word

In collaboration with the Technical Centre for Agricultural and Rural Co-operation (CTA), WARDA organized a workshop on *Information and Communication Technologies and Agricultural Institutional Development* in November 1998, at the

Table 4. *Internet/e-mail connections provided through the AfricaLink project to end 1998*

Status	*Countries*	*Institutions*	*Sites*
Connected	*15*	*29*	*91*
Funds provided	*4*	*7*	*8*
Being processed	*6*	*4*	*14*
Information needed	*8*	*10*	*10*
Request under review	*1*	*1*	*6*
Total†	*26*	*51*	*125*

† Totals are not simple sums of columns, as there are overlaps.

Training is an important component in bringing information technology to West African researchers

Observations on the AfricaLink Project

The AfricaLink Project enabled the Agriculture, Forestry and Fisheries Sector of the Council for Scientific and Industrial Research (CSIR) and two of its agricultural-based research institutes—the Crops Research Institute and the Savanna Agricultural Research Institute—to be hooked to the Internet and to have access to electronic-mail. Being connected to the Global Village has increased our communication links with international research centers and national agricultural research systems. It has also enabled us to communicate faster and cheaper with these bodies, and to transmit large volumes of data. Access to the information superhighway has also provided us with the opportunity to share relevant information, which can be utilized to achieve our common objectives.

Prior to our being hooked to the Net, the means of communication for research institutions was through facsimile, telephone, ordinary mail, and through traveling several kilometers to deliver whatever information was meant to be disseminated. This was often slow, expensive or time-consuming. Access to the Net has revolutionized our means of communicating with each other. Furthermore, an information gateway has been opened that can help reduce the shortage or absence of magazines, encyclopedias, books and databases in places where they should abound, such as libraries of research institutions. Though we realize that the Internet is not a panacea to the lack information resources at our research institutions, we appreciate the complementary role that it can serve.

Initially it was thought that the first phase of the AfricaLink Project would have provided for Internet connectivity for the 8 research institutes of the CSIR and the Faculties of Agriculture of the 4 universities. Realizing the enormous potential that we stand to gain from this facility we were spurred on to explore the possibility of securing funding for the computers in our institutions to be networked and connected to the Net. We believe that when this is achieved it will enable as many scientists as possible to have access to electronic-mail addresses so they can also communicate with their peers effectively—sharing ideas and discussing whatever research activities that they may be engaged in. It would also provide them with an opportunity to have access to a wealth of information on the Internet.

We look forward to the day when the information resources within the sub-region can be shared and exchanged electronically. It is hoped that with a tap of the keyboard it would be possible to look up information on a particular commodity that is cultivated in another country in the sub-region.

Having access to an electronic-mail address and the Internet has been exciting and it is hoped this revolution that is sweeping across the world will become available to a lot more scientists in Ghana.

—Prof. J.C. Norman, Deputy Director-General (Agriculture, Forestry and Fisheries), CSIR, Ghana

The presence of the Ivorian Minister of Research, Prof. Francis Wodié (second from left), highlighted the importance of the workshop for member states

Regional Training Center of Winrock International in Abidjan, Côte d'Ivoire. Some 30 senior NARS personnel (mostly directors) from 11 West and Central African countries attended the workshop, along with 10 resource persons from WARDA, CTA, the Centre de suivi écologique (Senegal), the Centre de coopération internationale en recherche agronomique pour le développement (CIRAD, France), the Food and Agriculture Organization of the United Nations (FAO), the Gondwana Africa Regional Office (South Africa) and Côte d'Ivoire. The national decision-makers were briefed on the potential of modern information and communication technologies, to encourage them to adopt policies and strategies to promote institutional development. The workshop focused on access to the Internet and its services, agricultural databases, electronic publishing and communication, geographical information systems (GIS), management information systems, multimedia, and other information technologies.

With vital funding from USAID, WARDA has given the opportunity for Internet and electronic-mail connection to some 91 national agricultural research and extension sites in West and Central Africa, providing access to nearly 1000 national researchers. A second phase of the project has been proposed to take the next step of training the connected scientists in information retrieval and management. This second phase is due to be under the aegis of CORAF, but with continued input from WARDA. As we enter the third millennium, more and more national scientists and extension agents in West and Central Africa can feel part of the global information network, with all that implies to the quality of their research results and personal performance.

What our partners say about the project

"The e-mail connection rendered us a great service—no more expenses for sending reports by express mail or courier. Also, ordinary mail takes such an unthinkable time!

"A baby must grow up. We now wish to have a server to make communication link with other agricultural research centers within the country."

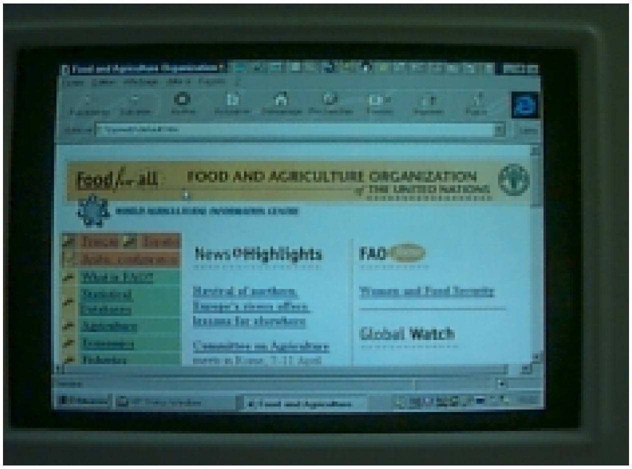
—K. Tetevi, Scientific Director, Institut togolais de recherche agricole (ITRA), Togo

"Thanks to our Internet connection, we are no longer isolated from the rest of the world. We advertised scientist positions on the ABG Web-site, and received a lot of applications."

—Odile Tahouo, Sous-directeur de l'information scientifiques et techniques, Centre national de recherche agronomique, Côte d'Ivoire

"This project has been beneficial for our institution. I hope that the second phase will be just as satisfactory."

—Dady Demby, Responsable du Département de l'information et de la communication, CORAF–Dakar, Senegal



With an Internet connection, national researchers can access global agricultural information

Donor Country Profile: Japan

WARDA'S RELATIONSHIP with Japan goes back to the early days in Liberia. Japan has probably been our most loyal and consistent supporter. In this first in a series of reviews of WARDA's relationships with specific donors, we look at a collaboration that extends far beyond mere financial support.

Rice has been the traditional staple food in Japan since time immemorial. West African rice consumption and production have increased sharply over the past 20 years or so, fueled by urban immigration and the preference of urban populations for rice over traditional staples such as sorghum, millet, yam and cassava. So, Japan has a long-standing interest in rice and many years of research and production experience. Japan is also the largest development aid donor in the world, so it is not surprising that WARDA has found support and encouragement from the Japanese Government and research and development organizations in pursuing its goal to improve both the livelihoods of rice farmers and food security in West Africa.

Funding history

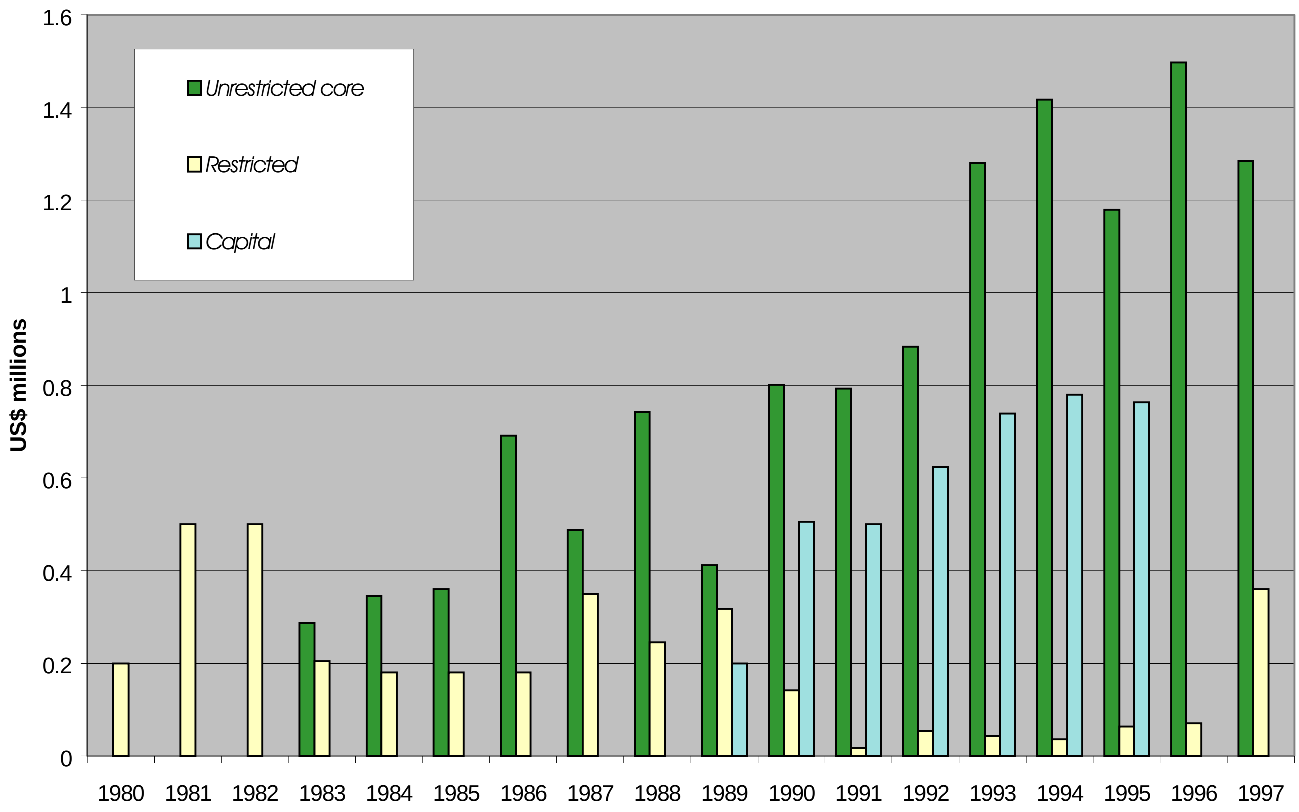
Japan is perhaps the largest long-term donor to WARDA—in 1997, the country provided almost 18% of WARDA's total budget! The breakdown of this funding by unrestricted core, special project and capital is given in Figure 10. Funding per se is channeled through the Ministry of Foreign Affairs (MFA), while experts are provided by the Japan International Cooperation Agency (JICA) and the Japan International Research Center for Agricultural Sciences (JIRCAS).

Early days

Japanese support to WARDA began back in 1978, when two rice processing experts were posted to WARDA's station at Fendall in Liberia. These experts were instrumental in establishing WARDA's first Rice Post-Harvest Technology Unit at the Fendall station; however, all this infrastructure was lost with the outbreak of civil war in Liberia and the relocation of WARDA staff to M'bé, Côte d'Ivoire. Encouraged by the success of the earlier venture, Japan continued its support of the postharvest work, and—through the person of its fifth rice processing expert—established a new Grain Quality/Post-Harvest Technology Unit at M'bé. Still today, Japan provides WARDA with its grain quality expert—the sixth such secondee—who came to Côte d'Ivoire in 1996.

The development of the work and infrastructure for WARDA's Grain Quality Laboratory has been carried out through the Japan International Cooperation Agency (JICA). As a bilateral cooperation agency, JICA's role is to supply experts, infrastructure and operational funds in a holistic approach to development assistance. The JICA package to WARDA also includes support staff and their needs. The early phase of the project focused not only on technical cooperation (the establishment of the facility), but also on training (creating the local expertise). In this way, some 240 national scientists were trained in grain quality/

Figure 10. Japanese funding to WARDA, 1980–1997



postharvest handling techniques between 1980 and 1989, so that they could establish similar facilities in their home countries.

Relocation

With the relocation to Côte d'Ivoire, and especially with the arrival of Hideo Watanabe in 1996, the emphasis of the JICA/WARDA grain quality project shifted toward research. This research has focused on three main areas:

- milling characteristics of rice grain, and selecting grain for high market value
- assessing grain quality of rice, and selecting varieties with good grain quality
- nutrition.

Under the first of these themes, surveys have been conducted on rice markets throughout the region to assess the value of different qualities of rice—for example, how much of a premium does good quality (high proportion of unbroken grain, or known popular variety) rice command on the market over poorer quality (many broken grains, or unpopular variety) rice. Such information provides economic justification for specific recommendations on rice grain handling to improve quality, if the better quality rice is sufficiently more expensive on the market. It may also help millers and wholesalers target rice of differing qualities at markets which will appreciate the differences. It is no good suggesting that a mill improve its handling of rice grain, if its target market sells all qualities of rice at the same price; conversely, we may recommend that a mill target a different market with its higher quality grain, if that market sells good grain at a premium.

At the same time, the project has conducted surveys of rice grain mills in the region, determining the milling capacity and quality of the various mills, and enabling us to target our marketing information at specific mills that can use it. As a backup to this work, field experiments have been conducted on grain quality maintenance. The final quality of rice grain depends not only on the way it is handled during harvest and processing, but also on certain aspects of the way it is grown. As an example of this, our work in Senegal showed that the timing of the application of nitrogen fertilizer has an effect on the resistance of the harvested grain to breakage: application of nitrogen fertilizer late in the season (10 days before heading) increases yield, milling recovery and grain quality. Grains that are handled roughly during harvest and postharvest processing are likely to be broken, scratched or otherwise damaged. Such damage affects the cooking quality of the grain, and therefore its price. Thus, we also make recommendations to farmers and millers on appropriate grain handling.

The grain quality of newly developed varieties is assessed on almost 40 characteristics, ranging from physical and biochemical features to cooking qualities, aroma and taste. Work with farmers and consumers alike has shown that the most important qualities that West Africans look for in the rice they eat are texture, aroma and taste, although different groups may have different preferences within these qualities. The grain quality work is done in close collaboration with the rice breeders, and enables quality to be used as a criterion in selecting new varieties.

Japanese scientists posted at WARDA, 1978–1998

Position	Name	Dates
Rice-processing/Grain Quality Experts (JICA)		
	K. Furugori	1978–1980
	T. Akutsu	1978–1980
	M. Kita	1979/80–1981
	H. Miyaishi	1982–1987
	M. Takeda	1888–1993
	H. Watanabe	1996–present
Visiting Scientist (JIRCAS)		
	S. Tobita (Physiologist/Molecular Biologist)	1998–present
Post-Doctoral Fellow (WARDA)		
	K. Futakuchi (Interspecific Hybridization Project)	1997–present

Nutritional value of rice

Nutrition work on rice is built around two basic features of rice itself: first that rice does not have a high protein content, and second that despite this low protein content rice does have auseful amino-acid complement. Amino acids are the building blocks of proteins and the relative abundance of each within a grain affects the overall nutritional quality of that grain. Therefore, there is potential for rice to provide valuable dietary components, especially for the rural and urban poor.

Palatability tests are an essential component of grain quality testing

The famous WARDA breakthrough with the 'new rice for Africa' sometimes seems too good to be true. In addition to all the other good things offered by the interspecific hybrid progenies, many of them have higher protein contents in their grain than either of their parents. This makes the value of rice in the diets of resource-poor farmers potentially even higher. In 1997, the first 200 interspecific progeny lines were screened for yield and protein content, and by the end of 1998 the best 50 had been selected. In 1999, the best 10 lines will be selected from these, and screening will begin of the next generation of progenies coming out of the breeding program.

Collaboration with Japanese agricultural research

The Japan International Research Center for Agricultural Sciences (JIRCAS) is a Japanese national research center, which also cooperates with international organizations like CGIAR Centers. In 1998, WARDA and JIRCAS established a five-year collaborative program. JIRCAS provides the research scientist to WARDA, while WARDA provides office, laboratory and field space, as well as administrative support. JIRCAS will also fund research assistants and technicians, and provides a certain amount of essential equipment, either direct from Japan or by funding for local purchase. The first JIRCAS scientist joined WARDA in January 1998. Satoshi Tobita is working with the Interspecific Hybridization Project on genetic and physiological characterization of *Oryza glaberrima* and interspecific progenies (*O. glaberrima* × *O. sativa*), focusing on drought resistance and tolerance to soil acidity. The aim is to develop a method for rapid assessment of whether newly bred rice lines have these desired traits, through a system known as 'marker-assisted selection'—a 'marker' gene (or group of

A recent JIRCAS short-term mission to WARDA, seen here visiting on-farm trials at Man (Côte d'Ivoire)

genes) which indicates the presence of the gene for the trait, and which can be easily detected in any of the plant's cells. In this case, the markers will be genes known as quantitative trait loci (QTLs).

The JIRCAS/WARDA program also includes short-term assignments for JIRCAS staff to visit WARDA, and for WARDA staff to visit JIRCAS and other research institutions in Japan.

The 'new rice for Africa' is given a high profile by Japanese donors and collaborators alike

Focus on the 'new rice for Africa'

In October 1998, Japan organized the Second Tokyo International Conference on African Development (TICAD II), at which it reconfirmed its commitment to the goal of "reducing poverty and integrating Africa with the global economy through accelerated economic growth and sustainable development." The development action agenda states "Improving production and competitiveness of agricultural ... industries is necessary because [it has] the potential to create jobs and products for export." The meeting emphasized the importance of developing rice farming in Africa, including specific mention of WARDA's Interspecific Hybridization Project and Asian-type irrigated rice farming—both of which are to be targeted for development and extension.

In recent years, the MFA has become the major donor to the Interspecific Hybridization Project, through the United Nations Development Programme's Technical Cooperation among Developing Countries (UNDP/TCDC). This support complements the roles of JICA and JIRCAS.

In addition, the MFA funds a postdoctoral fellow working with the Interspecific Hybridization Project, Koichi Futakuchi, who is assessing the value of the 'new rice for Africa' in lowland cropping (the plants were originally bred for upland cropping). The traditional African rice (*O. glaberrima*) occurs not only in the uplands, but also in the lowlands, so it is possible to use lowland *glaberrimas* in the interspecific crosses, with the aim of developing new rice plant types for these systems. Some *glaberrimas* also have the advantage of being adapted to flood conditions, not to mention their resistance to drought and weeds, which were target traits for the original upland work. Dr Futakuchi started work in May 1997 and, so far, has screened 200 progenies for yield and weed competitiveness in rainfed lowland and hydromorphic environments, and 300 progenies in irrigated lowland environments. Several progenies combined vigorous growth (see *Allies in the War on Weeds* in this report) with good height (tall plants)—both essential adaptations to lowland cropping. A further 10 progenies gave high yields (more than 6 tonnes per hectare) in rainfed lowland cropping with a moderate level of fertilizer. The chlorophyll content of the leaves seems to be a good indicator for final grain yield. Chlorophyll is the chemical which captures energy from sunlight to enable plants to manufacture sugars, and therefore feed themselves. Screening numbers of progeny on this trait is likely to identify lines with greater yield potential than the varieties currently grown by lowland farmers. Specific yield trials are underway for 50 lines selected in the lowland screening. Work also started in 1998 on the performance of some 30 lines under deep-water conditions.

Additional research under the Interspecific Hybridization Project is being conducted in collaboration with Tokyo University, to assess adaptations of *O. glaberrima* to submergence (flood conditions).

New avenues

The Japanese Ministry of Agriculture, Forestry and Fisheries recently started a project in Côte d'Ivoire, on Community Based Participatory Swamp Reclamation, under the umbrella of the World Food Programme and the Ivorian Government. The training and applied research components of this project involve WARDA. The main areas of WARDA's contribution will be participatory diagnosis, water and nutrient management systems, participatory varietal selection, community-based seed production, technology testing and transfer, health (nutrition and diseases) and socioeconomics (land tenure, market access and credit).

A successful partnership

Japan and WARDA have been working together for 21 years. It is a partnership that has grown and benefitted not only the partners themselves, but also the rice farmers of West Africa. In recent years, the collaboration has expanded to involve more Japanese institutions and fields of research. In 1999, the second JIRCAS scientist—Takeshi Sakurai, an economist—will move to WARDA. We at WARDA have enjoyed the collaboration to date, and are looking forward to our continued work with Japan well into the next millenium.

Financial Statement†

1. Position for the year ended 31 December 1998 (in US$)

ASSETS	1998	1997
Current Assets		
Cash and Bank Balances	1 669 204	1 600 884
Accounts Receivable:		
Donors	1 694 246	1 786 232
Employees	201 862	387 961
Others	864 039	1 720 858
Inventories	832 388	875 754
Prepaid Expenses	57 925	147 701
Other Current Assets	0	0
Total Current Assets	5 319 664	6 519 389
Fixed Assets		
Property, Plant and Equipment	18 936 253	18 025 237
Less: Accumulated Depreciation	(4 941 190)	(4 316 385)
Total Fixed Assets (Net)	13 995 063	13 708 852
TOTAL ASSETS	**19 314 727**	**20 228 242**
LIABILITIES AND FUND BALANCES		
Current Liabilities		
Cash and Bank Balances (Overdraft)	808 166	174 084
Accounts Payable:		
Donors	2 675 826	2 584 062
Employees	187 039	206 085
Others	1 234 384	2 243 600
Provisions and Accruals	1 053 154	1 245 583
Total Current Liabilities	**5 958 569**	**6 453 414**
Total Liabilities	**5 958 569**	**6 453 414**
Net Assets		
Capital Invested in Fixed Assets		
Center-owned	13 995 063	13 708 852
Capital Fund	281 933	783 757
Operating Fund	(920 838)	(717 781)
Total Net Assets	**13 356 158**	**13 774 828**
TOTAL LIABILITIES AND NET ASSETS	**19 314 727**	**20 228 242**

†Figures for 1998 are subject to ratification by the WARDA Board of Trustees.

2. Statement of activities by funding for the years ended 31 December 1997 and 1998 (in US$)

	Unrestricted	Restricted	Total 1998	Total 1997
REVENUE				
Grants	5 201 835	2 813 333	8 015 168	9 015 236
Member States' Contributions	762 497		762 497	382 739
Other Income	305 974		305 974	140 636
TOTAL REVENUE	**6 270 306**	**2 813 333**	**9 083 639**	**9 538 611**
OPERATING EXPENSES				
Research Programs	3 202 331	2 699 296	5 901 627	6 268 254
Administration and General Operations	2 931 510		2 931 510	3 251 606
Depreciation	625 600		625 600	738 663
Gross Operating Expenses	6 759 441	2 699 296	9 458 737	10 258 523
Recovery of Indirect Costs	(291 459)		(291 459)	(359 582)
OPERATING EXPENSES (NET)	6 467 982	2 699 296	9 167 278	9 898 941
EXCESS/(DEFICIT) OF REVENUE OVER EXPENSES	**(197 676)**	**114 037**	**(83 639)**	**(360 330)**
Allocated as Follows:				
Operating Funds	197 676		197 676	762 547
Capital Funds		(114 037)	(114 037)	(402 217)

MEMO ITEM

Operating Expenses by Natural Classification

	Unrestricted	Restricted	Total 1998	Total 1997
Personnel Costs	*3 869 754*	*837 619*	*4 707 373*	*4 924 730*
Supplies and Services	*1 831 297*	*1 629 179*	*3 460 476*	*3 722 897*
Operational Travel	*432 790*	*232 498*	*665 288*	*872 233*
Depreciation	*625 600*		*625 600*	*738 663*
Gross Operating Expenses	***6 759 441***	***2 699 296***	***9 458 737***	***10 258 523***

3. Grants for the year ended 31 December 1998 (in US$)

Unrestricted research agenda

	1998	1997
Canada	478 077	546 275
Côte d'Ivoire	109 176	152 652
Denmark	342 772	231 932
France	121 296	71 526
Germany	349 627	341 214
Japan	1 367 018	1 284 245
Korea		49 980
Netherlands	260 824	256 057
Norway	293 403	160 560
Sweden	473 100	470 396
United Kingdom	106 542	197 378
United States of America	200 000	200 000
World Bank	1 100 000	900 000
Total unrestricted grants	**5 201 835**	**4 862 215**

Restricted research agenda

African Development Bank (Institutional Support)		275 468
Canada (Laval University Project)	48 579	3 543
Canada (Vector-borne Diseases Project)	365 631	327 651
Canada (FDCIC Project)	11 111	
Denmark (Phytosanitary and Seed Health Project)	22 671	163 644
Denmark (Vector-borne Diseases Project)		139 605
European Union (Crop and Resource Management Project)		301 268
France (Agrophysiology Project)	74 488	63 387
France (Inland Valley Consortium Project)	100 248	99 950
Gatsby Foundation (Containment Facility)		1 740
Germany (GTZ) (Temperature Stress Project)		143 223
Germany (GTZ) (Pesticides Project)	14 448	52 471
Germany (GTZ) (Peri-urban Project)		2 912
Germany (GTZ) (Soil Nitrogen Project)	17 673	200 588
Germany (GTZ) (Projet riz nord)	40 499	
Germany (GTZ) (Improved Nutrient Management)	59 910	
IFAD (RADORT Project)	277 226	189 334
Japan (Post-doctoral Studies)	57 542	25 125
Japan (Grain Quality Studies)	98 892	72 593
Japan/UNDP (TCDC Project)	427 000	262 338
Netherlands (Inland Valley Consortium Project)	361 297	722 453
Norway (Vector-borne Diseases Project)	34 555	138 603
Norway (Training Project)	72 967	124 054

Restricted research agenda (continued)

	1998	1997
Rockefeller Foundation (Anther Culture Project)	157 745	103 722
United Kingdom (Weeds Project)		2 612
United Kingdom (Weeds/Insect Interaction Project)		6 693
United Kingdom (Nematology Project)	11 065	44 560
United Kingdom (RYMV Project)		21 764
United Kingdom (Blast Project)		23 850
United Kingdom (RYMV Holdback Project)	38 000	18 630
United Kingdom (Soil Degradation Holdback Project)	33 590	11 714
United Kingdom (Seed Priming Project)	11 732	
United States of America (USAID) (Arkansas Linkage Project)	5 712	3 089
United States of America (USAID) (Network Project)	356 670	330 071
United States of America (USAID) (Technology Dissemination Project)	50 286	83 971
United States of America (USAID) (Africa Link Project)	63 797	192 394
Total restricted grants	**2 813 333**	**4 153 020**
Total Grants	**8 015 168**	**9 015 235**

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Office of the Director General

Director General	Kanayo F. Nwanze
Executive Assistant to the Director General	P.-Justin Kouka

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Head of Finance	George Maina*
Interim Head of Finance	Shey R. Tata**
Head of Farm Management and Engineering Services	Chitti Babu Buyyala
Human Resources Officer	Gabriel Dao

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Interim Director of Programs	Willem Stoop**
WARDA's Interim Coordinator in Nigeria	Olumuyiwa Osiname*
Biometrician	Abdoulaye Adam
Documentalist	Alassane Diallo
Information Officer	Guy Manners*
Acting Training Coordinator	Abdoulaye Adam
INGER-Africa Coordinator	Robert Guei
Quarantine/Biosafety	Yacouba Séré

Program 1: Rainfed Rice

Systems Analyst/Program Leader	Michael Dingkuhn**
Upland Rice Breeder/Program Leader	Monty P. Jones
Lowland Rice Breeder	B.N. Singh
Agronomist/Breeder (Visiting Scientist)	Amadou Moustapha Bèye*
Cropping Systems Agronomist	Mathias Becker
Production Economist	Timothy J. Dalton
Agricultural Economist	Nina Lilja
Pathologist	Yacouba Séré

Entomologist (Visiting Scientist)	Francis Nwilene*
Soil Physicist	Sitapha Diatta
Soil Chemist	Kanwar Sahrawat
Molecular Biologist	Thierry Cadalen*

Program 2: Irrigated Rice

Irrigated Rice Breeder/Program Leader	Kouamé Miézan
Rice Breeder (Visiting Scientist)	Sié Moussa
Irrigation Agronomist	Marco Wopereis
Production Economist	Cynthia Donovan**

Program 3: Policy Support

Policy Economist/Program Leader	Thomas Randolph**
Program Leader	Amir Kassam*
Human Health Project Coordinator	Thomas Teuscher

Program 4: Information and Technology Transfer

Program Leader	Brent Simpson*
Acting Program Leader	Abdoulaye Adam

Collaborating Scientists

Grain Quality Specialist (JICA)	Hideo Watanabe
Physiologist/Molecular Biologist (JIRCAS)	Satoshi Tobita*
Crop Ecophysiologist (University of Tokyo/MAFF)	Koichi Futakuchi
Physiologist (CIRAD)	Alain Audebert
Inland Valley Consortium Regional Coordinator (CIRAD)	Jean-Yves Jamin
Inland Valley Consortium Research Coordinator (SC-DLO)	Peter Windmeijer
Nematologist (NRI)	Daniel Coyne**
Weed Scientist (NRI)	David Johnson
Crop Modeler (Laval University/CIDA)	Folkard Asch
RADORT Project Coordinator (Winrock International)	Niels Hannsens
Water Management Specialist (IWMI)	Wilfried Hundertmark*

* Joined in 1998
** Left in 1998

Training

Courses Given in 1998

Title and dates	Location	Language	Participants		
			Male	Female	Total
Participatory Rice Improvement and Gender Analysis / Amélioration variétale du riz par les paysans et l'analyse du genre 11–19 May	M'bé, Bouaké, Côte d'Ivoire (WARDA)	English, French	20	0	20
Bio-ecology and Management of the African Rice Gall Midge 5–16 October	Ibadan, Nigeria (IITA)	English, French	17	1	18
Improvement of Farmer-saved Seed: A New Approach for Sustainable Subsistence Agriculture 26–31 October	Man, Côte d'Ivoire	French	10	10	20
Atelier CTA/ADRAO sur les technologies de l'information, de la communication et le développement des institutions agricoles 24–26 November	Abidjan, Côte d'Ivoire (Winrock International)	French	20	3	23
Total					**91**

Postgraduate Trainees in 1998

Name and thesis topic	Institution	Sponsor	Degree
Akanvou, René Optimizing rice–cover legume intercropping in inland valleys in West Africa: A systems approach to interspecific competition	Wageningen Agricultural University	Netherlands/ WARDA	PhD
Bognonkpe, Jean Pierre Irenée La dynamique de l'azote natif du sol pendant la période de transition dans les principaux systèmes rizicoles de Côte d'Ivoire	University of Cocody, Abidjan	WARDA/ GTZ/BMZ	DEA
Diène, Rokhaya Samba Riziculture et dégradation des sols en vallée du fleuve Sénégal : analyse comparée des fonctionnements hydro-salines des sols du delta et de la moyenne vallée en simple et double riziculture	Université Cheikh Anta Diop Dakar, Senegal	AfDB	PhD
Guèye, Mor Analyse des contraintes liées aux pratiques culturales et à la gestion de la fertilité des sols à Podor et Matam	Université Gaston Berger, Saint-Louis, Senegal	GTZ	DEA
Guèye Talla Caractérisation génétique de la réponse du riz à l'azote en riziculture irriguée au Sahel	University of Hambourg	GTZ/DAAD	PhD
Häfele, Stephan Improved and sustainable nutrient management of irrigated rice-based cropping systems in West Africa	University of Hamburg	GTZ	PhD
Hoang, Tien Salinity tolerance in irrigated rice	Wageningen Agricultural University	DFID	MSc
Jalloh, Alpha Bella Genetics of iron toxicity tolerance in *indica* rice	University of Sierra Leone	AfDB	MPhil
Kane, Alassane Analyse des contraintes liées aux pratiques culturales et à la gestion de la fertilité des sols en Mauritanie	Université Gaston Berger Saint-Louis, Senegal	GTZ	DEA
Maji, A.T. Genetics of resistance to African rice gall midge in *Oryza glaberrima*	University of Ibadan	Rockefeller Foundation	PhD

Masiyandima, Mutsa Impact of land use on recharge to shallow groundwater	Cornell University	Rockefeller Foundation	PhD
Ndour, Daba Essais de caractérisation agromorphique et génétique de la tolérance à la salinité chez *Oryza sativa* L. dans le delta du fleuve Sénégal	Université Cheikh Anta Diop Dakar, Senegal	DFID	DEA
Ouassa, Anne-Marie Control of mosquito populations in Gambian rice fields	University of Abidjan/Institut Pierre Richet	AfDB/WARDA (Health Consortium)	PhD
Ouattara, Hadja Amziata† Stratégies de gestion socio-économique des bassins versants et contraintes à l'adoption des technologies rizicoles dans les zones agro-climatiques de Gagnoa, Danané, Boundiali et Touba	Université de Bouaké	IVC	DEA
Seynou, Idrissa Enhancing nutrient cycling in rice–legume rotations through phosphate rock in acid soil	Ecole Nationale d'Agronomie de Yamoussoukro	Ecole Nationale d'Agronomie de Yamoussoukro	DAA
Somado, Eklou Attiogbévi Enhancing nutrient cycling in rice–legume rotations through phosphate rock in acid soil	University of Göttingen	DAAD	PhD
Timmerman, Henk-Jan The impact of land use intensity on soil degradation	University of Amsterdam	IVC/ University of Amsterdam	MSc

Ouattara, Hadja Amziata†

Mr A.T. Maji in a field of *O. glaberrima* used in genetic studies of gall midge resistance

† Miss Ouattara passed away on 14 October 1998.

Publications

Abo, M.E. and A.A. Sy, 1998. Rice virus diseases: epidemiology and management strategies. *Journal of Sustainable Agriculture* 11(2/3): 113–134.

Abo, M.E., A.A. Sy and M.D. Alegbejo, 1998. Rice yellow mottle virus (RYMV) in Africa: evolution, distribution, economic significance on sustainable rice production and management strategies. *Journal of Sustainable Agriculture* 11(2/3): 85–111.

ADRAO, 1998. *ASI : une nouvelle batteuse-vanneuse améliore la productivité du riz irrigué en Afrique de l'Ouest* [folder]. ADRAO/WARDA, Bouaké, Côte d'Ivoire, 6 p.

ADRAO, 1998. *De nouveaux riz pour l'Afrique*. ADRAO/WARDA, Bouaké, Côte d'Ivoire, 20 p.

ADRAO, 1998. *Rapport annuel 1996.* ADRAO/WARDA, Bouaké, Côte d'Ivoire, 60 p.

Andriesse, W., T.J. Stomph and P.N. Windmeijer, 1998. Agro-ecological characterization: a tool for research priority setting and technology transfer. In: J.Y. Jamin and P.N. Windmeijer (ed.) *Proceedings of the First Scientific Workshop of the Inland Valley Consortium, Bouaké, Côte d'Ivoire, 1995.* WARDA, Bouaké, Côte d'Ivoire, pp. 31–46.

Baset, A., S. Tobita, C. Li, S. Yashima and T. Senboku, 1998. Micropropagation and *in vitro* culture of wild rice species. *Acta Horticulturae* 461: 259–266.

Becker, M. and D.E. Johnson, 1998. Legumes as dry season fallow in upland rice-based systems of West Africa. *Biology and Fertility of Soils* 27(4): 358–367.

Becker, M., D.E. Johnson and Z.J. Segda, 1998. The role of legume fallows in intensified upland rice-based systems of West Africa. In: D. Buckles, A. Etéka, O. Osiname, M. Galiba and G. Galiano (ed.) *Cover Crops in West Africa: Contributing to Sustainable Agriculture*. IDRC, Ottawa, Canada; IITA, Ibadan, Nigeria; Sasakawa Global 2000, Cotonou, Benin, pp. 85–106.

Buckles, D., A. Etéka, O. Osiname, M. Galiba and G. Galiano (Ed.), 1998. *Cover Crops in West Africa: Contributing to Sustainable Agriculture / Plantes de couverture en Afrique de l'Ouest : Une contribution à l'agriculture durable*. IDRC, Ottawa, Canada, 291 p.

Carsky, R.J., S.A. Tarawali, M. Becker, D. Chikoye, G. Tian and N. Sanginga, 1998. Macuna: a cover legume with potential for multiple uses. *Resources and Crop Management Division (RCMD) Research Monograph* no. 25. Resources and Crop Management Program, International Institute of Tropical Agriculture (IITA), Ibadan, Nigeria. 54 p.

Coyne, D.L. and R.A. Plowright, 1998. Use of solarisation to control *Heterodera sacchari* and other plant parasitic nematodes in the field: a modified technique for experimental purposes. *International Journal of Nematology* 8(1): 81–84.

Coyne, D.L., R.A. Plowright, B. Thio and D.J. Hunt, 1998. Plant parasitic nematode diversity and prevalence in traditional upland rice in Ivory Coast: preliminary observations on the effects of cropping intensification. *Fundamental and Applied Nematology* 21(6): 723–732.

Dalton, T.J. and W.A. Masters, 1998. Pasture taxes and agricultural intensification in southern Mali. Special issue: Food security, diversification, and resource management —refocusing the role of agriculture. *Agricultural Economics* 19(1-2): 27–32.

Diatta, S. and K.L. Sahrawat, 1998. Performance de quatre cultivars de riz avec et sans engrais sur sol gris sableux de bas versant dans la région centrale de la Côte d'Ivoire. In: G. Renard, A. Neef, K. Becker and M. von Oppen (ed.) *Soil Fertility Management in West African Land Use Systems*: *Proceedings of the Regional Workshop held at Niamey, Niger, 4–8 March 1997*. Margraf Verlag, Weikerheim, Germany, pp. 155–159.

Diatta, S. and Siband, P. 1998. Evolution des sols sous culture continue : le cas des sols rouges ferralitiques du sol du Sénégal. In: G. Renard, A. Neef, K. Becker and M. von Oppen (ed.) *Soil Fertility Management in West African Land Use Systems*: *Proceedings of the Regional Workshop held at Niamey, Niger, 4–8 March 1997.* Margraf Verlag, Weikerheim, Germany, pp. 221–229.

Diatta, S., A. Audebert, K.L. Sahrawat and S. Traoré, 1998. Lutte contre la toxicité ferreuse du riz dans les bas-fonds des savanes en Afrique de l'Ouest. In: N. Ahmadi and B. Teme (ed.) *Aménagement et mise en valeur des bas-fonds du Mali. Bilan et perspectives nationales, intérêt pour la zone de savane ouest-africaine : Actes du séminaire, 21–25 octobre 1996, Sikasso, Mali.* Colloques, CIRAD, Montpellier, France, pp. 363–371.

Diatta, S., R. Bertrand, A. Herbillon and K.L. Sahrawat, 1998. Genèse des sols d'une séquence sur granito-gneiss en région centre de la Côte d'Ivoire. Actes du 16ème Congrès Mondial de Science du Sol/Proceedings of the 16th World Congress of Soil Science, 20–26 août/August 1998, Montpellier, France. CIRAD, Montpellier, France. CD-ROM Symposium/Workshop 15. Code 124.

Dingkuhn, M., M.P. Jones, D.E. Johnson and A. Sow, 1998. Growth and yield potential of *Oryza sativa* and *O. glaberrima* upland rice cultivars and their interspecific progenies. *Field Crops Research* 57: 57–69.

Dionisio-Sese, M.L. and S. Tobita, 1998. Antioxidant responses of rice seedlings to salinity stress. *Plant Science* 135(1): 1–9.

FAO, IITA, WARDA/ADRAO and IVC/CBF (Food and Agriculture Organization of the United Nations, International Institute of Tropical Agriculture, WARDA and Inland Valley Consortium), 1998. *Regional Workshop on Sustainable Development of Inland Valley in Sub-Saharan Africa, Cotonou, Bénin, 29 January to 2 February 1996 / Atelier régional sur la mise en valeur durable des vallées intérieures humides en Afrique sub-saharienne, Cotonou, Bénin, 29 janvier au 2 février 1996. Proceedings/Actes*. FAO, Accra, Ghana, Volume 1, 115 p.; Volume 2, 569 p.

Jamin, J.Y., P.N. Windmeijer and M. Mahaman, 1998. Diversité agroécologique des bas-fonds des savanes ouest-africaines : représentativité régionale des travaux effectués au sud du Mali. In: N. Ahmadi and B. Teme (ed.) *Actes du séminaire : Aménagement et mise en valeur des bas-fonds au Mali, Sikasso, Mali, 1996.* CIRAD, Montpellier, France, pp. 299–308.

Jamin, J.Y. and P.N. Windmeijer (Ed.), 1998. *Characterization of Inland Valley Agro-ecosystems: A Tool for their Sustainable Use. Proceedings of the First Scientific Workshop of the Inland Valley Consortium, Bouaké, Côte d'Ivoire, 1995 / La caractérisation des agro-écosystèmes de bas-fonds : un outil pour leur mise en valeur durable. Actes du premier atelier scientifique du Consortium bas-fonds, ADRAO, Bouaké, 6–10 novembre 1995.* WARDA/ADRAO, Bouaké, Côte d'Ivoire, 325 p.

Johnson, D.E. 1998. *Les adventices en riziculture en Afrique de l'Ouest / Weeds of Rice in West Africa*. ADRAO/WARDA, Bouaké, Côte d'Ivoire, 312 p.

Johnson, D.E., M. Dingkuhn, M.P. Jones and M.C. Mahamane, 1998. The influence of rice plant type on the effect of weed competition on *Oryza sativa* and *Oryza glaberrima*. *Weed Research* 38: 207–216.

Lilja, N. and J.H. Sanders, 1998. Welfare impacts of technological change on women in Southern Mali. *Agricultural Economics* 19: 73–79

Mahaman, M. and P.N. Windmeijer, 1998. Exemple d'utillisation d'un système d'information géographique pour la caractérisation agro-écologique multi-échelle des bas-fonds. In: J.Y. Jamin, and P.N. Windmeijer (ed.) *Proceedings of the First Scientific Workshop of the Inland Valley Consortium, Bouaké, Côte d'Ivoire, 1995.* WARDA, Bouaké, Côte d'Ivoire, pp. 191–202.

Narteh, L.T. and K.L. Sahrawat, 1998. Prediction of nitrogen availability to rice in West Africa soils. *Oryza* 35(3): 193–201.

Nwanze, K.F., 1998. *WARDA: Looking Back into the Future*. WARDA, Bouaké, Côte d'Ivoire, 16 p.

Nwanze, K.F., F.E. Nwilene and Y.V.R. Reddy, 1998. Evidence of shoot fly *Atherigona soccata* Rondani (Dipt., Muscidae) oviposition response to sorghum seedling volatiles. *Journal of Applied Entomology* 122(9-10): 591–594.

Nwanze, K.F., F.E. Nwilene and Y.V.R. Reddy, 1998. Fecundity and diurnal oviposition behaviour of sorghum shoot fly, *Atherigona soccata* Rondani (Diptera: Muscidae). *Entomon* 23(2): 77–82.

Nwanze, K.F., Y.V.R. Reddy, F.E. Nwilene, K.G.Kausalya and D.D.R. Reddy, 1998.Tritrophic interactions in sorghum, midge (*Stenodiplosis sorghicola*) and its parasitoid (*Aprostocetus* spp.). *Crop Protection* 17(2): 165–169.

Nwilene, F.E. and K.F. Nwanze, 1998. Cultural control of insect pests in tropical crops. In: G.S. Dhaliwal and E.A. Heinrichs (ed.) *Critical Issues in Insect Pest Management*. Commonwealth Publishers, New Delhi, India, pp. 26–66.

Nwilene, F.E., K.F. Nwanze and Y.V.R. Reddy, 1998. The effect of sorghum ecosystem diversification and sowing date on shoot fly, stem borer and associated parasitoids. *Crop Research* 16(2): 239–245.

Okocha, P.I. and B.N. Singh, 1998. Evaluation of some promising rice breeding lines for tolerance to iron toxicity. *Global Journal of Pure and Applied Sciences* 4(2): 117–120.

Sahrawat, K.L. 1998. Flooding soil: a great equalizer of diversity in chemical fertility. *Oryza* 35: 300–305.

Sahrawat, K.L. 1998. Short-term incubation method for mineralizable nitrogen. *Arid Soil Research and Rehabilitation* 12: 291–295.

Sahrawat, K.L. 1998. Soil phosphorus status and natural growth of *Azolla* in irrigated lowland rice. *Current Science* 75: 548.

Sahrawat, K.L. and B.N. Singh, 1998. Seasonal differences in iron toxicity tolerance of lowland rice cultivars. *International Rice Research Notes* 23(1): 18–19.

Sahrawat, K.L., M.P. Jones and S. Diatta, 1998. Plant phosphorus and rice yield in an ultisol of the humid forest zone in West Africa. *Communications in Soil Science and Plant Analysis* 29(7-8): 997–1005.

Sahrawat, K.L., T.J. Rego, M.H. Rahman and J.K. Rao, 1998. Phosphorus response effects on macro- and micronutrient removal by sorghum under rainfed cropping on a Vertisol. *Journal of the Indian Society of Soil Science* 46: 58–60.

Sidibe, A. and Y. Séré, 1998. The demand for fertilizer on upland rice in the south-west of Burkina Faso: determinants and cost and returns analysis. In: G.A.A. Wossink, G.C. Van Kooten and G.H. Peters (ed.)

Economics of Agro-chemicals: An International Overview of Use Patterns, Technical and Institutional Determinants, Policies and Perspectives. Selected Papers of the Symposium of the International Association of Agricultural Economists held at Wageningen, The Netherlands, 24–28 April 1996. Ashgate Publishing, Aldershot, UK, pp. 207–213.

Sie, M., M. Dingkuhn, M.S.C. Wopereis and K.M. Miezan, 1998. Rice crop duration and leaf appearance rate in a variable thermal environment. I. Development of an empirically based model. *Field Crops Research* 57: 1–13.

Sie, M., M. Dingkuhn, M.S.C. Wopereis and K.M. Miezan, 1998. Rice crop duration and leaf appearance rate in a variable thermal environment. II. Comparison of genotypes. *Field Crops Research* 58: 129–140.

Sié, M., M. Dingkuhn, M.C.S. Wopereis and K.M. Miezan, 1998. Rice crop duration and leaf appearance rate in a variable thermal environment. III. Heritability of photothermal traits. *Field Crops Research* 58: 141–152.

Stomph, T.J., W. Andriesse, L.O. Fresco, N. de Ridder and P.N. Windmeijer, 1998. Multi-scale characterization and modelling. In: J.Y. Jamin and P.N. Windmeijer (ed.) *Proceedings of the First Scientific Workshop of the Inland Valley Consortium, Bouaké, Côte d'Ivoire, 1995.* WARDA, Bouaké, Côte d'Ivoire, pp. 121–132.

WARDA, 1998. *Annual Report 1997.* WARDA, Bouaké, Côte d'Ivoire, 72 p.

WARDA, 1998. *ASI: A New Thresher/Cleaner Improves West African Irrigated Rice Productivity* [folder]. WARDA, Bouaké, Côte d'Ivoire, 6 p.

WARDA, 1998. *Focus: Interspecifics*. Africa–Asia Joint Research on Interspecific Hybridization between African and Asian Rice Varieties. Highlights of 1998 Activities. WARDA, Bouaké Côte d'Ivoire, 24 p.

WARDA, 1998. *New Rice for Africa*. WARDA, Bouaké, Côte d'Ivoire, 20 p.

WARDA, 1998. *Report of the First Biennial WARDA/National Experts Committee Meeting, 30–31 January 1998, M'bé/Bouaké, Côte d'Ivoire. WARDA Technology Transfer Strategy and Evolution of Rice Task Forces*. Biennial WARDA/National Experts Committee Meeting reports N° 1. WARDA, Bouaké, Côte d'Ivoire, 66 p.

Windmeijer, P.N., 1998. Agro-ecological characterization of inland valleys. In: FAO, IITA, WARDA/ADRAO and IVC/CBF. *Regional Workshop on Sustainanle Development of Inland Valley in Sub-Saharan Africa, Cotonou, Bénin, 29 January to 2 February 1996. Proceedings.* FAO, Accra, Ghana, pp. 1–15.

Windmeijer, P.N. and J.Y. Jamin, 1998. Methods and minimum data sets for agro-ecological characterization of inland valleys: main results of the workshop. In: J.Y. Jamin and P.N. Windmeijer (ed.) *Proceedings of the First Scientific Workshop of the Inland Valley Consortium, Bouaké, Côte d'Ivoire, 1995.* WARDA, Bouaké, Côte d'Ivoire, pp. 13–38.

Windmeijer, P.N., W. Andriesse, N. van Duivenbooden and S.A. Lamin, 1998. A classification system for inland valley agro-ecosystems. In: FAO, IITA, WARDA/ADRAO and IVC/CBF. *Regional Workshop on Sustainanle Development of Inland Valley in Sub-Saharan Africa, Cotonou, Bénin, 29 January to 2 February 1996. Proceedings.* FAO, Accra, Ghana, p. 33–52.

Windmeijer, P.N., T.J. Stomph, A. Adam, R. Coppus, N. De Ridder, M. Kandeh, M. Mahaman and M. Van Loon, 1998. Transect sampling strategies for semi-detailed characterization of inland valley systems. *Netherlands Journal of Agricultural Science* 46(1): 15–25.

Wopereis, M.C.S., J. Ceuppens, P. Boivin, A.M. Ndiaye and A. Kane, 1998. Preserving soil quality under irrigation in the Senegal River Valley. *Netherlands Journal of Agricultural Science* 46(1): 97–107.

Acronyms

ADRAO	Association pour le développement de la riziculture en Afrique de l'Ouest (French name of WARDA)
AfDB	African Development Bank
AGETA	Association générale des groupements d'exploitants et éleveurs pour l'étude et l'emploi de techniques améliorées agricoles et animales (Mauritania)
ANADER	Agence nationale d'appui au développement rural (Côte d'Ivoire)
BAD	Banque africain de développement (French name of African Development Bank)
CBF	Consortium bas-fonds (French name of IVC)
CGIAR	Consultative Group on International Agricultural Research
CIDA	Canadian International Development Agency
CIRAD	Centre de coopération internationale en recherche agronomique pour le développement (France)
CORAF	Conférence des responsables de la recherche agricole en Afrique de l'Ouest et du Centre
CRA	Centre de recherche agricole (part of ITRA, Togo)
CSIR	Council for Scientific and Industrial Research (Ghana)
CTA	Technical Centre for Agricultural and Rural Co-operation
DAAD	Deutscher Akademischer Austauschdienst
DEA	Diplôme d'études approfondies (degree)
DFID	Department for International Development (*formerly* ODA, UK)
DGIS	Directorate General for International Cooperation (The Netherlands)
DPDR	Planning and Rural Development Department (part of SAED, Senegal)
ECA	Economic Commission for Africa
Ed./ed.	editor(s)
FAO	Food and Agriculture Organization of the United Nations
FARA	Forum for Agricultural Research in Africa
GIS	geographical information system(s)
GTZ	Gesellschaft für Technische Zusammenarbeit (Germany)
IARC	international agricultural research center
IDRC	International Development Research Centre (Canada)
IHP	Interspecific Hybridization Project (WARDA)
IITA	International Institute of Tropical Agriculture
ILRI	International Livestock Research Institute
INERA	Institut de l'environnement et des recherches agricoles (Burkina Faso)
INGER	International Network for the Genetic Evaluation of Rice
IPTRID	International Program for Technology Research in Irrigation and Drainage
IRD	Institut de recherche pour le développement (*formerly* ORSTOM, France)
IRRI	International Rice Research Institute (Los Baños, The Philippines)
ISRA	Institut sénégalais de recherches agricoles (Senegal)
ITRA	Institut togolais de recherche agricole (Togo)

IVC	Inland Valley Consortium
IWMI	International Water Management Institute
JICA	Japan International Cooperation Agency
JIRCAS	Japan International Research Center for Agricultural Sciences
LANADA	Laboratoire national d'appui au développement agricole (Côte d'Ivoire)
MAFF	Ministry of Agriculture, Forestry and Fisheries (Japan)
MFA	Ministry of Foreign Affairs of Japan
MPhil	Master of Philosophy (degree)
MSc	Master of Science (degree)
N	nitrogen
NARI	National Agricultural Research Institute (The Gambia)
NARS	national agricultural research system(s)
NCRI	National Cereals Research Institute (Nigeria)
NGO	non-governmental organization
NRI	Natural Resources Institute (UK)
ODA	Overseas Development Administration (*now* DFID, UK)
OECD	Organisation for Economic Co-operation and Development
ORSTOM	Institut français de recherche scientifique pour le développement en coopération (*now* IRD, France)
PhD	Doctor of Philosophy (doctorate)
PNR	Projet national riz (Côte d'Ivoire)
QTL	quantitative trait locus
RADORT	Research on Accelerated Diffusion of Rice Technology (project)
RCMD	Resources and Crop Management Division (IITA)
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)
SC-DLO	Winand Staring Centre for Integrated Land, Soil and Water Research (Wageningen, the Netherlands)
SPAAR	Special Program for African Agricultural Research (World Bank)
TAC	Technical Advisory Committee (CGIAR)
TCDC	Technical Cooperation among Developing Countries (UNDP)
TICAD II	Second Tokyo International Conference on African Development
UK	United Kingdom
UNDP	United Nations Development Programme
URDOC	Unité de recherche pour le développement observatoire de changement (Mali)
USA	United States of America
USAID	United States Agency for International Development
WARDA	West Africa Rice Development Association
WAU	Wageningen Agricultural University

Credits

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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.

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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 (Manila, Philippines)
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)

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