WARDA ANNUAL REPORT 1986

WEST AFRICA
RICE DEVELOPMENT
ASSOCIATION

The West Africa Rice Development Association (WARDA) is an autonomous intergovernmental scientific research organization made up of 16 West African member states: Benin, Burkina Faso, Chad, The Gambia, Ghana, Guinea, Guinea Bissau, Cote d'Ivoire, Liberia, Mali, Mauritania, Niger, Nigeria, Senegal, Sierra Leone and Togo.

WARDA was established in 1970 with the assistance of the United Nations Development Program UNDP), the United Nations Food and Agriculture Organization (FAO) and the Economic Commission for Africa (ECA). In November 1986, it became a full-fledged member of the Consultative Group on International Agricultural Research (CGIAR), a network of 13 international agricultural centres.

The mandate of WARDA is to assist its member countries in becoming self-sufficient in rice, a staple food of West Africans.

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III.

WARDA's DONORS (1986)

The West Africa Rice Development Association (WARDA) receives funds and assistance, in kind, from the following:

- Member Countries

- CGIAR funds from the following countries and agencies: Belgium, Canada, Federal Republic of Germany, France, Japan, The Netherlands, and Sweden; World Bank, International Fund for Agricultural Development, and the Rockefeller Foundation.

- International and regional organizations and private foundations, namely: World Bank, International Institutre of Tropical Agriculture (IITA), United Nations Food and Agriculture Organization (FAO), United Nations Development Program (UNDP), and the European Economic Community (EEC); and

- International aid agencies of governments of the following countries: Belgium, Federal Republic of Germany, France, Italy, Japan, The Netherlands, Switzerland, and the United States of America.

F O R E W O R D

1. The year 1986 stands out as one of the most eventful in the annals of WARDA; it has seen remarkable vicissitudes in the fortunes of the Association.

2. Following two years of serious financial crisis and uncertainty about the future of the Association, the decision of the Governing Council in December 1985 delegating policy-making responsibilities to the Scientific and Technical Committee created optimism in the future of the Association. This optimism evaporated when the TAC Mid-Term Review reported continuing governance, management and financial problems.

3. At the request of the CGIAR, an IDRC Mission conducted by Mr. Moise Mensah, Assistant President, IFAD, visited the sub-region in July to negotiate changes in WARDA's governance and management structures. The Mission recommended:

(1) The redesignation of the Governing Council as the Council of Ministers

(2) the reconstitution of the STC into a Board of Trustees with the same powers and functions as the Boards of other IARCs

(3) the redesignation of the position of Executive Secretary as Director General and changes in the process for filling the position.

4. The Resolution on WARDA passed by the Heads of States of WARDA member countries in Abuja, July, dispelled doubts about the interest of WARDA member states in the Association and enabled the Governing Council meeting in August to accept the recommendations made by Mr. Mensah.

5. The acceptance of the changes in WARDA's governance and management structures removed a major obstacle to continued CGIAR funding of WARDA and resulted in the CGIAR's decision to finance WARDA on the same basis as other IARCs. The formal amendment of the WARDA constitution in December 1986 set the seal to these changes and ushered in "the new WARDA."

6. The resolution of WARDA's governance and funding problems comes out of a strong will and determination on the part of WARDA member countries and donors to promote collaboration between West African countries and north/south co-operation in the fight against hunger. It will help ensure sound management of the organisation and end the funding uncertainties that have hampered WARDA's activities and operations for a very long time.

7. WARDA Scientists feel excited about this situation which offers them a real opportunity to plan and implement, under stable funding conditions, a well-integrated and coherent research and training program addressing the major environmental constraints that limit the productivity of our rice farmers and the quantity of rice produced in West Africa.

Alieu M. B. Jagne
Acting Executive Secretary

REGIONAL UPLAND RICE RESEARCH STATION, BOUAKE, COTE D'IVOIRE

VARIETAL IMPROVEMENT

GERMPLASM EVALUATION AND UTILIZATION

Evaluation of New Upland Rice Colection

The new set of upland germplasm evaluated in 1986 included 141 varieties from Madagascar, 75 varieties from Togo and 60 from Guinea. Also, 20 O. glaberrima varieties from Togo were tested. Two drought periods which occurred during the growing season enabled very reliable scoring for drought tolerance. Table 1 illustrates the results obtained from screening for different traits.

Many of the germplasms, particularly those from Madagascar, appeared to be useful for the hybridization programme. While no one Glaberrima variety was found to be resistant to two or more diseases, many were found to be resistant to leaf and neck blast.

Variety Trial of Elite Germplasm and Reselection

The replicated trial was conducted at Bouake, Man and Odienne. At Bouake, there was drought during the growing period but at Man and Odienne, there was no drought. The average yield, life cycle and plant height are shown in Table 2. In the trial, 48:27:27:kg NPK/ha was applied. No plant protection chemical was used. Unit plot size was $20m^2$.

Table 1: A general evaluation of germplasm studied in 1986

	Varieties	
	O. sativa	O. glaberrima
Number of entries	276	29
Per cent of varieties tolerant to drought	22	65
Per cent of varieties resistant to most diseases	24	0
Per cent varieties maturing in less than 130 days	3	0
Per cent varieties having more than 150 grains/panicle	21	0
Per cent varieties having more than 10 panicles/plant	26	31

Table 2: Average yield, flowering duration and plant height of entries of variety trials conducted at Bouake, Man and Odienne in 1986.

Variety	Average Yield in kg/ha	Average Flowering Duration	Average Plant Height in cm
MALOUKA	2116	111	136
WABMA	1980	114	128
IAC 164 (check)	1978	84	121
WABC 165	1975	84	122
WABZI	1929	101	131
AZI	1865	100	131
MOROBEREKAN (check)	1806	118	142
WABUKA	1716	111	127
GBAHOMA	1470	123	139
WABSOKA	1446	119	139
TOUBABOU	1275	122	147
WABOU	1226	122	154

As anticipated, IAC 164 and WABC 165 turned out to be earliest among the entries and WABZI and AZI of medium duration. Other varieties and selections were found to be of longer duration. Grain yield of MALOUKA was consistently good at all the locations. Considering grain yield, duration, panicle size and disease resistance, WABC 165 and WABZI deserve special attention in farmers' field trials.

Although they did not give higher average yield, these varieties are considered much safer and dependable in terms of suitable duration, plant type, disease resistance, acceptable grain type and manganese toxicity tolerance. WABC 165 has long slender grains and WABZI short slender grains. These two varieties have proven their drought tolerance. Both have much better manganese toxicity tolerance than most others. WABC 165 is tolerant to acid soil while WABZI is moderately tolerant. Both have white rice.

Preliminary Variety Trials of Selected Germplasms

In three different preliminary trials at different sites, promising entries were WABIS 677, WABIS 701, WABIS 550, WABIS 675, WABIS 600 and IR 59331-110-1. These will be used for multilocation advanced variety trials.

BREEDING PROGRAM

In 1986, 129 crosses were made and nine crosses, in F2, were supplied by IRRI at the request of the WARDA breeder. Among 129 crosses made, 21 were three way crosses, 28 double crosses and the remaining were single crosses. A total number of 188 F1 plants were grown from the crosses made in 1985. Nine F2 populations generation advancement from IRRI were planted in November 1986.

Out of 68 F2 populations grown at Bouake, 2509 lines were selected from 33 populations. Similarly from 17 F3 families, 320 lines were selected, and from eight F4 populations 195 lines were selected. Forty superior uniform lines were selected from three F3 populations. Eleven fixed lines were also selected from F6 populations. They will be further tested in observational trials in 1987.

Varietal Screening for Soil Acidity Tolerance

Soil acidity is a common problem in most upland rice areas in the region. In severe cases, the plant turns yellow, slows down its growth and yield is reduced. Little work has been done to test the tolerance levels of West African popular varieties and germplasm. It is believed that there is a wide range of tolerance level among the upland rice varieties of the region. Screening of available varieties will help in identifying tolerant ones for breeding purposes. The information can also be used by others.

Nineteen West African upland rice varieties, 38 selections from germplasms and 22 F6 fixed lines, were put together in this test to determine their level of tolerance to soil acidity. An area with acid soil was chosen at the Bouake Station. Soil water pH at planting time was: 5.0, 4.9, 4.9 and 5.1 at four sites in the experimental area.

Observations were taken after first symptoms started showing. Data was taken 62, 82 and 95 days after seeding. In most areas, the symptoms increased as the plants became older.

Quite a few varieties and lines showed tolerance to acidity up to the reproductive phase. Varieties and lines showing symptoms, in general, did not show any recovery. This will serve as a good basis for further research.

Study of Natural Mutants of Gbahoma

It was observed that a local Ivorian variety , GBAHOMA, when planted during the off-season for crossing in 1986, produced mutant spikelet in many panicles. The variety was observed in the experiments and in farmers fields during the 1986 main season and no mutant spikelets was found. GBAHOMA was planted again in the next off-season and mutants appeared again. It is certain that GBAHOMA produces mutant spikelets under adverse environmental conditions such as solar intensity or higher temperature or both that occur at Bouake at certain times. The types of mutants are shown below. Most of the mutants were found usually at the tip of panicles.

Multiple Grains	:	2 rice grains inside one spikelet. Usually both grains are reduced in size. Sometimes, one grain is rudimentary and the other one near normal.
Multi spikelets	:	2 lemmas, 2 paleas and more rudimentary ones clustered together. Often sterile. Rarely one caryopsis.
Bigger grains	:	Grains are unusually bigger than normal. Caryopsis exposed due to failure of glumes to hold.

Isolated mutant types are being studied. Efforts will be made to see if any useful mutant can be detected. It is expected that GBAHOMA will continue to mutate under the hot sunny conditions of Bouake.

Multilocation Trial of Short Duration Varieties

Six new short duration varieties were tested at Bouake, Man and Odienne on 15 m^2 plots. At Bouake, a drought period occurred just after sowing, resulting in poor vegetative development and low yield. At Man, despite a short drought period at tillering stage, there was fairly good vegetative development. At Odienne, there was good vegetative development. At Man, IDSA 6 was the highest yielder while IRAT 144 and WABIS 217 were the highest yielders at Odienne. IRAT 144 had a comparatively high incidence of leaf and neck blast at all locations.

INTERNATIONAL COLLABORATIVE TRIALS

Three trials were conducted in 1986. The detailed results will be published by the IRTP coordinators. In AURP88 (Africa Upland Rice Preliminary screening set) out of the 150 entries, 15 were selected for further evaluation. Eighteen varieties were selected for further evaluation in the Africa Upland Rice Observational Nursery (AURON). The Africa Upland Rice Advanced Trial (AURAT) was conducted at Bouake, Man, Odienne and Tombokro. From data collected at Man, IRAT 161 was the highest yielder with 3.2 ton/ha. ITA 257 which matured at 85 days was the earliest entry.

PEST CONTROL AND MANAGEMENT

Crop Loss Assessment

In 1986 three fungicides, Benlate, Kitazin and Kocide, were used to determine grain loss due to neck blast. These trials were conducted at Bouake and Tombokro. The three varieties used were Delta (susceptible), IRAT 112 (susceptible), and IAC 164 (resistant).

At Bouake, grain yield loss from the untreated plots of the Delta compared with the yields from similar plots treated with Benlate, Kitazin and Kocide were 49, 49 and 58 per cent respectively. In plots of IRAT 112, a moderately susceptible rice variety to neck blast, the loss in yield from the untreated plots was 32, 20, and 24 per cent for Benlate, Kitazin and Kocide respectively. IAC 164, a resistant variety to neck blast, produced yield losses of 2, 4 and 4 per cent for Benlate, Kitazin and Kocide respectively.

Considering all the reactions of the rice varieties and the efficiency of the fungicides, a range of yield loss from 2 to 58 per cent with an average of 27 per cent was obtained in Bouake.

In Tombokro, the yield loss obtained from Delta was 18.5% compared with yields from Kocide treated plots; 27 per cent compared with Benlate treated plots and 28 per cent compared with Kitazin treated plots. With respect to IRAT 112, the loss in yield by the untreated plots was 27 per cent (Kocide); 28 per cent (Benlate) and 32 per cent (Kitazin). As for IAC 164, the loss ranged from 2 per cent (compared with Benlate and Kocide treated plots) to 3 per cent (Kitazin). The overall range of yield loss for Tombokro was from 2 to 32 per cent with an average of 20 per cent.

The efficiency of the three fungicides was estimated from the results obtained. The percentage efficiency of Benlate at Bouake in reducing the incidence of rice blast ranged from 43 on IAC 164 to 72 on IRAT 112. A range of 41 per cent for Delta to 87 per cent for IRAT 112 was obtained for Kitazin. Kocide exhibited an efficiency range of 51 per cent on IAC 164 and 92 per cent on IRAT 112. Thus, the efficiency of a chemical is dependent on the virulence of the organism and the susceptibility of the variety.

ENTOMOLOGY

Varietal Screening

Screening many cultivars for varietal resistance was carried out at Bouake in the screen house in which optimum insect population level was maintained. Results revealed that stem borer infestation on test varieties in the screen house increased with age of the varieties. At 50 days after sowing (DAS), the percentage hills infested in all test varieties taken together was 68.6 (ranging from 21.4% in the most resistant to 94.4% in the most susceptible). At 70 and 100 DAS, they were 72.8 (range 20.0-100.0 per cent) and 77.5 (range 38.8-100.0 per cent) respectively. Percentage tillers with dead hearts were 13.4 (range 4.5-23.2 per cent) and 22.9 (range 11.5-34.6%) at 70 and 100 DAS respectively. Varieties that exhibited less infestation during the vegetative stage were WABUKA, WABYS 302, WABIS 764, WABIS 188, WABIS 560, SEL IRAT and IR 36. At the reproductive stage, the following varieties were least attacked: WABYS 121, WABIS 665, WABIS 574, WABUKA, WABYS 302 and WABIS 764. In overall performance at 50, 70, and 100 DAS, the following varieties stand out and are considered to be resistant: WABUKA, WABIS 764, IR 36 and WABIS 302. The most susceptible were W1263, WABIS 786 and B299-C-Tb-73-4-2-3-3-3-2. All test varieties appeared to be resistant to rice blast except W1263 which was nearly wiped out by seedling blast.

Tagged, selected lines in segregating populations on the field were regularly examined to ensure that they did not possess high levels of susceptibility to rice stem borers.

Control and Management

To study population dynamics of major insect pests of upland rice, a large field (30 x 30m^2) was planted with two rice varieties, Moroberekan and IAC 164 at two sites: Bouake and Tombokro. The plots were divided into four equal parts for

efficient sampling. Sowing was done by dibbling at a spacing of 25 cm x 25 cm. All cultural practices were as recommended: fertilizer application 120 kg N/ha and 60 kg/ha of P_2O_5 and KCl with two handweedings. From 30 days after sowing until harvest, insect pests were sampled using insect sweep nets, and rice stems were dissected at weekly intervals. All the insects collected were sorted out and the pests were identified. Results obtained from Tombokro which is a better site for the study than Bouake are briefly discussed.

In 1986, Tombokro continued to be a better site for studies on insect pests in the field in comparison with the experimental site at Bouake both in terms of pest diversity and abundance. A serious outbreak of the black beetle, Chaetocnema zeae occurred, affecting all the crops in the field. These insects scrape the upper leaf surface tissue and leave white streaks of uneaten lower epidermis between the parallel leaf veins. During the outbreak, all the plants in the field were affected with hardly any leaf left untouched. The beetles, however, disappeared as the crops reached the flowering stage. Apart from leaf damage which was widespread, no other injury was noticed. It is pertinent to mention that this species has been incriminated as vector of the Yellow Mottle Virus disease.

Major insect pests at the early vegetative stage were Epilachna similis, Diopsis macrophthalma, Diopsis apicalis, Nephotettix modulatus and Chaetocnema zeae. Epilachna and Chaetocnema had only one population peak occurring at 40 days after sowing. Thereafter, they disappeared from the field. Nephotettix and Diopsis had a second population peak occurring at 65 and 72 days after sowing respectively.

During the reproductive and maturity stages, the rice bugs, Stenocoris and Aspavia were the most important insect pests. These insects feed on the endosperm of the rice grain. The earwig, Diapersasticus erythrocephalus occurred right from the early vegetative stage up to crop maturity. The population level increased significantly during the flowering stage (Fig.1). These insects are known to feed mainly on the floral parts and immature grains. Of particular interest was the occurrence of the rice weevil, Sithophilus oryzae, in the field at crop maturity. Infestation began 86 days after sowing, increasing gradually until harvest. Field infestation by the grain weevil was absent in Bouake during the 1986 cropping season.

Five hundred and seven (507) stem borers were collected from the dissection of 720 rice hills. Out of these, 87% were Maliarpha separatella, 2.4% Chilo zacconius, 2.5% Sesamia calamistis and 8.1 % Diopsis spp. Infestation by lepidopterous stem borers started 60 days after sowing and steadily increased as the crop developed (Fig. 2). Peak borer infestation occurred

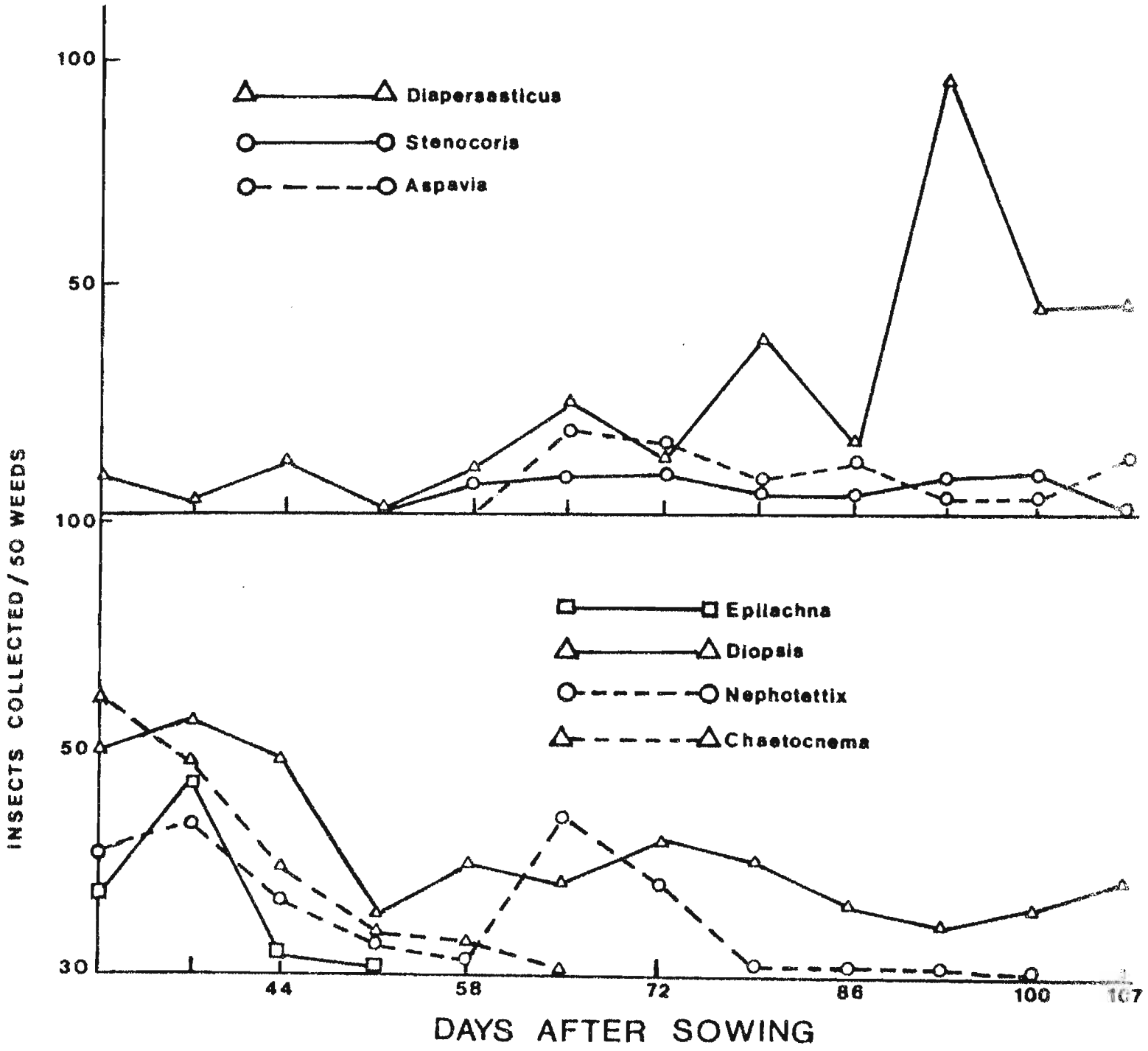


Fig.1: Population dynamics of major insect pests of upland rice at Tombokro, 1986

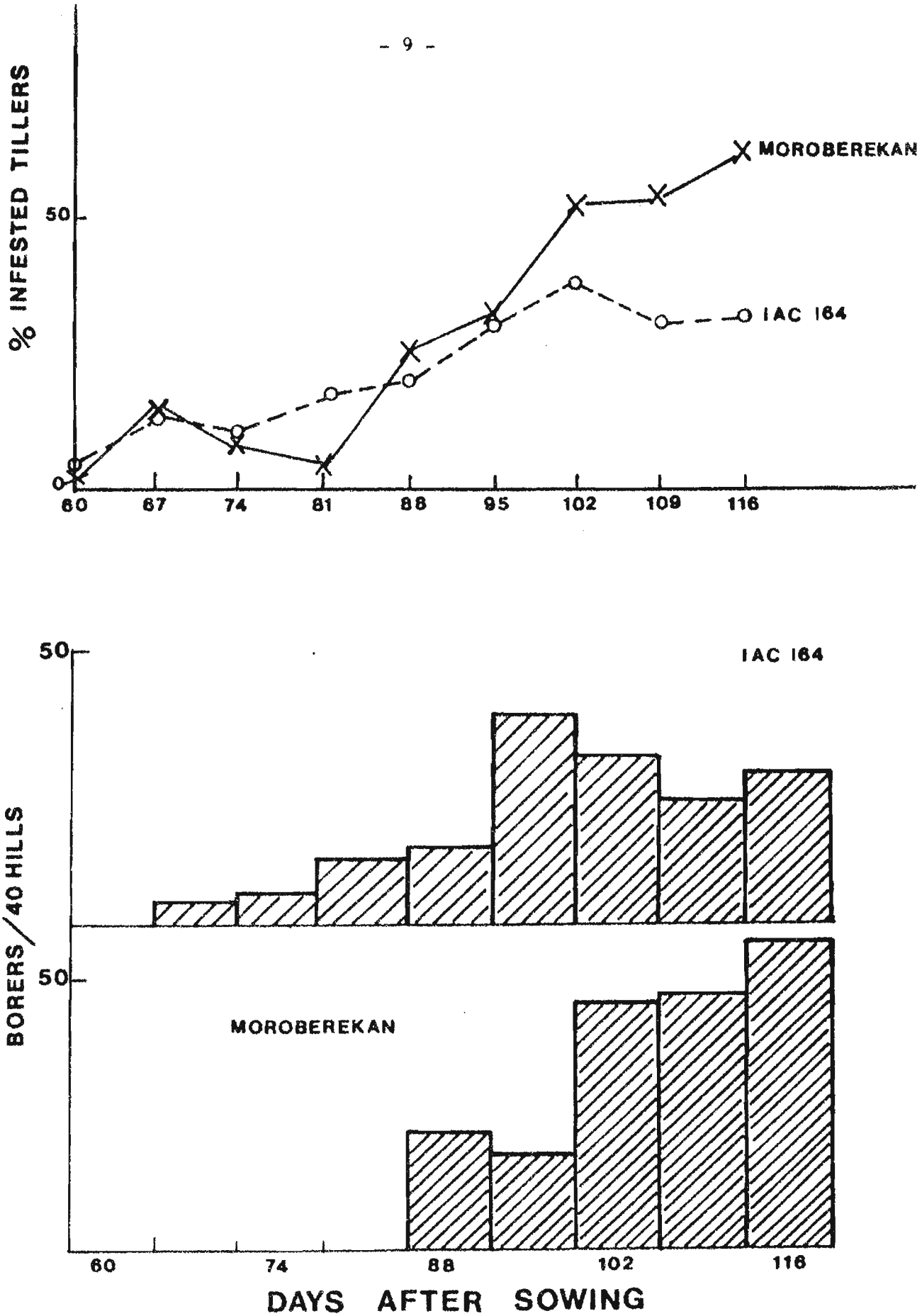


Fig. 2: Incidence of stem borers on two rice varieties at Tombokro, 1986.

at 102 and 116 days after sowing in IAC 164 and Moroberekan respectively. From flowering to crop maturity, the rate of infestation as well as the number of borer larvae collected were higher in Moroberekan than in IAC 164.

Yield Loss Assessment

Yield losses attributable to insect pest damage on upland rice were determined using two varieties, Moroberekan and IAC 164. Experiments were laid out with six treatments consisting of five commonly available insecticides and an untreated check.

There were very few deadhearts and white heads on the crop during the vegetative and reproductive stages of crop growth. At maturity, when rice tillers were dissected, many were found to lodge Maliarpha separatella.

At Bouake, yields obtained were very low. This was attributed to poor soil and continuous cropping. Differences, however, existed between protected and unprotected plots depending on the level of protection offered by the different treatments. The differences ranged from 5.6% to 36.3%.

At Tombokro, yield differences between protected and unprotected plots ranged from 2.55 to 11.75% in Moroberekan (Table 3) and 9.4 % to 20.5% in IAC 164 (Table 4).

Comparing the two sites, insect pests were less in Bouake than at Tombokro during the season but the margin of yield loss was larger at Bouake.

Table 3: Effects of insecticidal treatments on grain yield of rice variety Moroberekan. Tombokro 1986.

Treatments	% Stems attacked	Stem borers/ 10 hills	Yield (kg/ha)	%Yield Loss
LINDANE 10G	62.6	15	2021.5	11.0
FENITROTHION 60EC	67.2	18	1895.5	4.1
DECAMETHRINE 25EC	61.0	22	1886.0	3.6
FENITROTHION II	70.6	15	1866.5	2.5
CARBOFURAN 5G	49.2	8	2034.0	11.7
CONTROL	68.6	16	1820.5	
LSD			394.2	
CV			14%	

Table 4: Effects of insecticidal treatments on grain yield of rice variety IAC 164. Tombokro 1986.

Treatments	% Stems attacked	Stem borers/ 10 hills	Yield (kg/ha)	% Yield Loss
LINDANE 10G	28.2	8	1893.5	12.0
FENITROTHION 60EC	62.8	16	1928.0	14.0
DECAMETHRINE 25EC	42.3	12	1928.0	14.0
FENITROTHION II	48.1	11	1850.0	9.4
CARBURAN 5G	12.7	5	2037.5	20.5
CONTROL	51.4	19	1690.5	-
LSD				
CV			11%	

International Rice Stem Borer Nursery (IRSBN)

Eighty-one varieties of the 1985 IRSBN were grown at Tombokro for screening.

Very few deadhearts and whiteheads were observed on the nursery during the vegetative and reproductive stages of plant growth. At maturity, five rice hills were selected at random from each plot and the tillers were dissected. Out of a total of 852 stem borer larvae collected 79.4% were Maliarpha separatella, 3.5% Chilo zacconius, 7.6% Sesamia calamistis and the stalk-eyed flies, Diopsis spp. 9.5%. Percentage tillers infested by stem borers ranged from 6.4 to 46.7 and borer larvae collected on 5 hills ranged from 0 to 14.

The following 23 varieties and lines exhibiting less than 10% infested tillers and less than 2 borers per 5 hills were selected for more intensive evaluations in the screenhouse:

BR 109-74-2-2-2
BR 40-300-2-1
GEB 24
IR 11288-B-B-118-1
IR 13429-287-3
IR 15314-43-2-3-3
IR 15795-151-2-3-2-2
IR 19743-25-2-2
IR 19819-31-2-3
IR 21015-80-3-3-1-2
IR 22082-41-2
IR 3941-2-1-3
IR 42
IR 4619-57-1-1-2-1
IR 48
IR 52
IR 54
IR 5857-4-IE-3
IR 9109-72-2-1
IR 9129-169-3-2-3-3
IR 9703-41-3-3-1
IR 9830-26-3-3
TNAU 1756

WEED MANAGEMENT

Weed Surveys

Observations made in Cote d'Ivoire, Ghana and Sierra Leone show that the weed spectrum during the cropping period is a reflection of the vegetation before clearing. The weed flora consists of tree regrowth, broadleaf annuals, grasses, sedges, and ferns. Grasses dominate in the savannah zone and tree regrowth and ferns in the forest zone. The same weed species appear all over West Africa, with the major difference being in the degree of infestation. The following species are among the most widespread and troublesome: Rottboellia conchinchinensis L., Pennisetum spp., Digitaria spp., Pannicum spp. Imperata cylindrica, Cyperus spp. and Eupatorium odoratum L. Very little attention has so far been given to tree regrowth weeds. In traditional upland rice farming, these weeds can cause considerable crop losses due to their rapid growth and extensive area coverage.

Mechanical Control of Euphorbia Sceterophylla L.

Euphorbia heterophylla is a rapidly spreading weed in Cote d'Ivoire where rice in the field as well as the harvested crop are reported to have been abandoned because of the contamination of this weed. This trial was set up to investigate the frequency of tillage required per season in order to eliminate the weed in a heavily infested field.

The experimental site was a field heavily infested with E. heterophylla. The treatments are shown below:

Date	T0	T1	T2	T3
25 May	-	One disc plough + 2 passes disc harrow	One disc plough + 2 passes disc harrow	One disc plough + 2 passes disc harrow
22 June	-	-	2 passes disc harrow	2 passes disc harrow
26 July	-	-	-	2 passes disc harrow
30 August	2 passes disc har.	2 paases disc har.	2 passes disc har	2 passes\ disc har.

Fig. 3 shows the effect of tillage frequency on the biomass of E. heterophylla. One tillage did not reduce the weed population; instead, it stimulated the germination and growth of the weed. Two tillages reduced the weed population by about half and three tillages by 80%. It appears that more than three soil tillages in one season are necessary to eliminate a heavy infestation of E. heterophylla.

Because rice could not be sown after the last tillage, the effect of the treatment on the rice crop could not be assessed. Obviously, the 50% weed reduction by the two tillages may not guarantee satisfactory crop yield and quality, and the 80% weed reduction by the three tillages can still provide nucleus weed seed for the next cropping season. Thus, these two treatments require further weeding.

Chemical Weed Management in Rice-based Cropping Systems

Preliminary Herbicide Screening

The objective of this trial was to evaluate the effect of a set of herbicides on crops normally intercropped with rice.

One rice pre-emergent herbicide, oxadiazon at 1.0 kg a.i/ha, and two maize pre-emergent herbicides, cynazine-atrazine at 2.0 kg a.i./ha and atrazine-metolachlore at 2.8 kg a.i./ha were applied to rice intercropped with maize, sorghum, cowpeas, and groundnuts followed by one hand spot weeding. They were applied immediately after seeding.

Table 5 shows the effect of herbicides on the various crops. The three herbicides had no negative effect on the germination of the test crops except sorghum which had 40% germination when treated with oxadiazon, and 70% germination with both cynazine-atrazine and atrazine-metolachlore.

With regard to toxicity levels, cowpea was 100% tolerant, groundnuts 70%, maize 60% and sorghum 20% when treated with oxadiazon. For cynazine-atrazine, sorghum was 70% tolerant, rice and groundnuts 50%, and 10% for cowpea. Apart from maize, the most tolerant crop against atrazine-metochlore was groundnuts which exhibited 50% tolerance. Against oxadiazon, maize had 90% recovery while groundnuts and sorghum had 70% and 20% respectively. About 50% of rice, sorghum, and groundnuts could recover from cynazine-atrazine treatment. Only groundnuts had above 50% recovery.

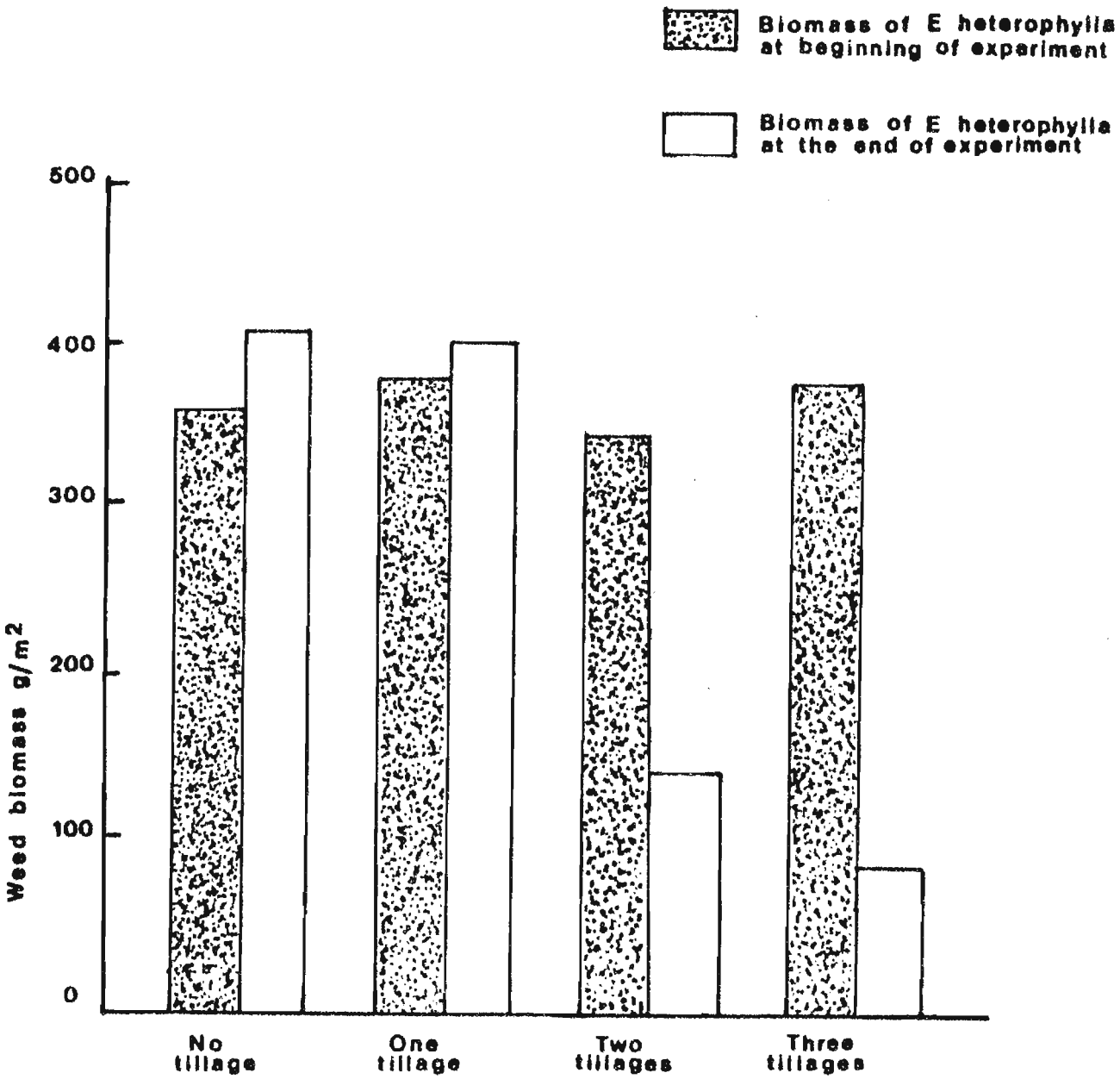


Fig. 3 : Effect of tillage frequency on the biomass g/m^2 of Euphorbia heterophylla L.

Table 5: Effect of some herbicides on various crops intergrown with rice

Crop	% Germination				Toxicity Rating (0-10)				% Recovery 10 Maturity				Crop Yield (kg/ha)				
	No-Tr	Oxad	Cy-At	At-M	No-Tr	Oxad	Cy-At	At-M	No-Tr	Oxad	Cy-At	At-M	No-Tr	Oxad	Cy-At	At-M	LSD 5%
Rice	100	100	100	100	0	1	5	8	-	100	50	20	3504	3499	1842	805	984
Maize	100	100	100	100	0	4	1	1	-	90	100	100	4867	3978	5042	4928	586
Sorghum	100	40	70	70	0	8	3	8	-	20	60	40	2203	428	871	378	784
Cowpea	100	100	100	100	0	0	9	9	-	100	0	0	2550	2605	0	0	298
Groundnuts	100	100	100	100	0	3	5	5	-	70	60	60	2541	1903	897	968	614

No-Tr = No herbicide application but plots kept weed free by hand weeding

Oxad = Oxidiazon 1.0 kg a.i./ha

Cy-At = Cynazine-atrazine 1 at 2.0 kg a.i./ha

At-M = Atrazine-metolachlore at 2.8 kg a.i./ha

1 Reach reproductive and maturity stage
2 A dash (-) = herbicide proprietary mixture

There were significant differences in crop yields between the control and the treatments for all the crops except cowpea treated with oxadiazon. Oxadiazon reduced maize yield to 80%, groundnuts to 70% and sorghum to 20%. The yield of cowpea, however, increased by 10%. Cynazine-atrazine significantly reduced rice grain yield, but about half the crop was harvested compared to about 30% for sorghum, cowpea and groundnuts. Except for maize, atrazine-metolachlore reduced yield of all crops to less than 35%. All herbicides had excellent weed control. The main weeds at the site in order of decreasing importance were: Euphorbia heterophylla L., Dactyloctenium aegyptium (L) P. Beauv., Digitaria Longiflora (Retz.) Pers., and Ageratum conyzoides L.

This preliminary observational experiment indicated that rice, maize, cowpea, and groundnuts can have little or no germination problems when treated with oxadiazon, cynazine-atrazine, and atrazine-metolachlore. There were different levels of toxicity reactions of these crops but maize and groundnuts showed better ability to recover than sorghum when treated with oxadiazon.

Direct Herbicide Application in Rice-based Cropping Systems

The experiment was to evaluate the degree of damage rice herbicides can do to crops intergrown with rice.

Rice at 30 cm spacing was intercropped with maize at 100 cm row spacing. In one treatment, rice and maize were sown at the same time and a post-emergence rice herbicide, bentazon-propanil at 4.0 kg a.i./ha was applied by directed spraying to the rice crop avoiding maize as far as possible. In another treatment, rice was sown 2, 3 and 4 weeks after sowing maize and pre-emergent herbicide, oxadiazon at 1.0 kg a.i./ha was applied to the seeded rice avoiding maize as far as possible. Injury to the maize crop was evaluated 10 days after application.

As can be seen in Table 6, bentazon-propanil (post-emergent) application appeared to have a higher risk than oxadiazon (pre-emergent). The highest damage appeared when bentazon-propanil was applied 2 weeks after rice/maize emergence resulting in the maize yield reduction of about 50%. Applying bentazon-propanil 3 weeks after rice/maize emergence reduced the maize yield by 25%. Oxadiazon reduced maize yield by 25% when applied to 2 weeks old maize, and it produced yields similar to untreated plots when applied to 3 weeks old maize. The following were the main weed species: Eleusine indica L., Digitaria ciliaris (Retz.) Koel., Rottboellia exaltata L., Ageratum conyzoides L., and Euphorbia heterophylla L.

The success of this study depends among other things, on the wind condition at the time of application. In this experiment, considerable herbicide drift might have given rise to a rather high degree of crop damage.

Split Herbicide Application

A single application of the recommended dose of bentazon-propanil (4.0 kg a.i./ha) was compared with split applications as shown in Table 7.

Results showed that a single application of the full recommended dose depressed rice yields by about 45% if compared to the weed free treatment (Table 7). This was due to the second infestation of weeds that occurred from about 2 weeks after application and that eventually became as profuse as the first infestation.

Table 6: Effect of directed spraying rice herbicides on the growth and yield of maize in rice/maize intercropping

Treatment	Mean maize toxicity rating (0-9)	Maize recovery to maturity %	Mean Crop Yield (kg/ha) Rice	Maize4
Weed free	-	-	3 105	4 295 a
Bentazon-propanil 4.0 kg a.i./ha 2 WAR/M	3.8	60	2 8122	1 989 c
Bentazon-propanil 4.0 kg a.i./ha 3 WAR/M	4.2	70	2 963	3 207 b
Bentazon-propanil 4.0 kg a.i./ha 4 WAR/M	8.0	90	3 090	3 898 a
Oxadiazon 1.0kg ai/ha 2WAM2	7.5	95	2 997	3 348 b
Oxadiazon 1.0kg ai/ha 3 WAM	9.2	100	3 025	4 194 a
Oxadiazon 1.0kg ai/ha 4 WAM	9.5	100	3 210	4 321 a

1. 2WAR/M = Weeks after rice and maize emergence
2. 2WAM = Weeks after maize emergence
3. Figures followed by the same letter are not significantly different at 5%.

Table 7: Effect of split herbicide application on weed control and rice grain yield.

Treatments			Mean weed control rating	Mean grain yield
Herbicide	Rate of split application (kg ai/ha)	Time application	(0-10)	(kg/ha)
No weeding	-		-	210 a3
Weed-free by hand weeding	-	4 times every 2 weeks	1.5	3 486 d
Bentazon-propanil1	4+0	20 DAE2	5.2	1 978 c
Bentazon-propanil	2+2	20 + 27 DAE	7.0	1 395 b
Bentazon-propanil	3+2	20 + 27 DAE	3.0	3 098 d
Bentazon-propanil	4+2	20 + 27 DAE	2.8	3 289 d

1. DAE = Days after emergence
2. Figures followed by the same letter are not significantly different at 5%.

Splitting the recommended dose into 2 equal parts did not improve herbicide efficiency. The weeds simply withered and started to regenerate after 10 days. However, rice yields similar to weed free plots were obtained when the herbicide was split in both the 3+2 kg and 4+2 kg active ingredient per hectare treatments. These two treatments did not require further weeding and can therefore be further studied for possible adoption. The main weeds at this site were: Brachiaria reptans (L.) Gard. L. Hubb., Dactyloctenium aegyptium (L.) P. Beauv., Digitaria horizontalis Wild., Sida acuta Burm., Ageratum conyzoides L., and Euphorbia heterophylla L.

Application of Reduced Herbicide Rates in Combination with Manual Weeding

For many small scale farmers, herbicide availability and cost are limiting factors but such farmers may have limited labour to supplement herbicide use. The aim of this experiment was to devise an integrated weed management system in

which weed control combines herbicide use and manual weeding in order to reduce herbicide and labour costs. Therefore, oxadiazon at rates lower than recommended (1.0 kg a.i./ha) was applied at rates of 0.25, 0.50, 0.75 and 1.0 kg a.i./ha with various combinations of 0, 1, 2, 3 and 4 weedings. The 4 weedings represented weed-free plots.

The main weed flora at this site consisted of Digitaria horizontalis Wild., Eleusine indica L., Ageratum conyzoides L., Rottboellia exaltata L. Euphorbia heterophylla L., and Dactyloctenium aegyptium L. P. Beauv.

Oxadiazon applied alone at half the recommended rate (0.5 kg a.i./ha) was as good as oxadiazon applied alone at 0.75 kg a.i./ha and 1.0 kg a.i./ha. About half the crop was harvested when only one quarter of the recommended rate was used alone. All oxadiazon treatments in combination with 1-3 hand weedings controlled weeds to the level that required no further weeding and produced rice yields similar to the recommended rate of 1.0 kg a.i./ha.

The experiment indicates that it is possible to use oxadiazon at rates as low as 0.5 kg a.i./ha without further weeding and get reasonably good rice yields. Crop yields can be greatly improved if these low rates are supplemented with hand weeding. Further trials will be conducted during 1987 at multilocational sites to evaluate other combinations and to subject the treatments to a wider weed spectrum.

CROP AND SOIL MANAGEMENT

CROP MANAGEMENT

Studies on Some Relay Cropping Systems under Bimodal Rainfall Conditions (e.g. Bouake)

Maize/Rice and Cassava/Rice are the cropping systems commonly practised by West African farmers. However, planting method and plant population do vary greatly. This trial was therefore conducted to:

- investigate suitable crop mixture practices with rice and other major food crops and
- develop appropriate cultural practices with a view to alleviating operational constraints in intercropping and relay cropping systems.

Maize/Rice Relay Cropping

The following treatments were used in the trial:

- 100% rice
- 75% rice/25% maize (i.e. 20,000 plants/ha)
- 50% rice/50% maize (i.e. 40,000 plants/ha)
- 25% rice/75% maize (i.e. 60,000 plants/ha)
- 100% maize (i.e. 80,000 plants/ha).

A short duration cowpea cultivar (IT84E-1-108) was also associated with the system.

Maize was seeded on April 25th and rice 38 days after maize and rice were harvested respectively 110 DAS and 130 DAS. After harvest, the maize plant residues served as mulch for rice. Matured cowpea pods were harvested (64-77 DAS).

Grain yields and plant residue of the two crops in various cropping systems are presented in Table 8. The table shows that rice yield decreased significantly as the proportion of the crop decreased. The highest grain yield (2.82 t/ha) was recorded at 40,000 maize plants/ha and decreased as the population increased from 60,000-80,000 plants/ha. In cowpea, however, the kernel yield increased as the proportion of the crop increased (1.74 t/ha in 100% cowpea). It can also be noted in Table 8 that the highest total yield was obtained with the system made up of 50% rice/50% maize/50% cowpea. This treatment also showed the highest land equivalent ratio (1.91).

Evaluation of Component Technologies

The objective was to develop suitable agronomic practices for upland rice grown under various agro-climatic conditions in West Africa. Different experiments were conducted for this investigation.

Effect of Plant Densities on Grain Yield and Yield Components of Three Rice Cultivars under Upland Conditions

The objectives of the experiment were:

- to determine optimum seed rates for upland rice cultivars having different 1000 grain weights

- to determine the suitable plant density under upland conditions with special reference to panicle number and filled spikelets per panicle.

Table 8: Maize/rice cowpea cropping systems: grain yields and weight of plant parts in various cropping treatments.

Cropping Systems	Grain Yields (t/ha) of Crops				Weight (t/ha) of Plant Residues				Total (t/ha)
	Maize	Rice	Cowpea	Total	Maize	Rice	Cowpea	Total	
1. 100% Rice	-	2.82	-	2.82	-	6.36	-	6.36	9.18
2. 75% rice/25% maize/ 25% cowpea	1.39 c	2.01 b	0.33 d	3.73	2.41	4.25	0.43	7.09	10.82
3. 50% rice/50% maize/ 50% cowpea	2.62 a	1.13 c	0.71 c	4.46	4.51	2.44	0.94	7.89	12.35
4. 25% rice/75% maize/ 75% cowpea	2.39 b	0.42 d	1.19 b	4.00	5.54	1.46	1.54	8.54	12.54
5. 100% maize/100% cowpea	2.38 b	-	1.74 a	4.12	6.59	-	2.25	8.84	12.96
L.S.D. (P = 0.05)	0.20	0.16	0.09						

Note:
100% Maize = 80,000 plants/ha
75% Maize = 60,000 plants/ha
50% Maize = 40,000 plants/ha
25% Maize = 20,000 plants/ha

100% Cowpea = 200,000 plants/ha
75% Cowpea = 150,000 plants/ha
50% Cowpea = 100,000 plants/ha
25% Cowpea = 50,000 plants/ha

a. Main plot: Plant density

D1 : 15cm x 20cm
D2 : 20cm x 20cm
D3 : 30cm x 20cm
D4 : 40cm x 20cm

b. Sub plot: Rice cultivars

-IRAT 144(V1) : 42g/1000 grains. semi tall; 110 days duration
-IAC 164(V2) : 34g/100 grains; semi-tall; 110 days duration
-IDSA 6(V3) : 25g/1000 grains; semi-dwarf 120 days duration

It can be seen in Table 9 that as far as IRAT 144 and IAC 164 are concerned, there was a yield increase as plant population per unit land area decreased. It can also be seen that the number of filled spikelets was much smaller in close spacing (15cm x 20cm). Thus the two short duration, semi-tall rice cultivars (IRAT 144 and IAC 164) under wider spacing, would give higher grain yield.

IDSA 6 was the least sensitive to drought among the cultivars. There was also little variation in yield at different spacings. However, filled spikelets per panicle increased with decrease in plant population per unit area.

IDSA 6, in all plant density, gave greater rice yield, number of panicles, filled spikelets and percentage of filled spikelets per panicle than IRAT 144 and IAC 164.

Response of Upland Rice to Time of Nitrogen Application in Monomodal High Rainfall Forest and Bimodal Savannah Ecologies

To develop appropriate technology for management of plant nutrients in rice-based cropping systems in various upland ecologies through suitable timing of nitrogen application, two field experiments, one each at Bouake (bimodal, savannah, drought prone zone) and Man (Monomodal long forest zone) were conducted during the 1986 season. At both locations a RCB design with four replications was adopted. Urea was used as a source of nitrogen. A basal application of phosphorus (TSP) and potassium (KCL) at the rate of 45Kg P_2O_5 and 45Kg K_2O respectively was given at both locations. At both sites the test variety was IDSA 6 (semi-dwarf, medium duration).

- In drought prone bimodal savannah area at Bouake, higher yield response over the control was obtained when nitrogen was applied in three split doses at 14, 29 and 53 DAS or at 14, 50 and 70 DAS. However, half of the

total quantity of applied nitrogen should be given at 14 DAS. For efficient utilization by the rice crop nitrogen should not be applied at the time of sowing of seeds. Similarly, nitrogen application in two split doses is not suitable in this zone.

- In monomodal high rainfall forest zone (at Man) three split doses at 15, 33, and 50 or at 15, 50 and 70 DAS are suitable for good yield response when high nitrogen level (80 Kg N/ha) is used. At low applied nitrogen level (40 Kg N/ha) 3-5 split nitrogen applications might be suitable for good yield response and to reduce leaching loss.

- At both sites, 80 Kg N/ha level gave higher yield response over control than 40 Kg N/ha level.

Table 9: Effect of plant density and rice cultivars on rice yield, and its components under upland conditions at Bouake (1986).

Density	IRAT 144				IAC 144				IDSA 6				Mean grain yield (t/ha)
	Grain yield (t/ha)	Panicle per sq.m.	Per Panicle: No. of filled spikelet	Per Panicle: Filled spikelet (%)	Grain yield (t/ha)	Panicle per sq.m.	Per Panicle: No. of filled spikelet	Per Panicle: Filled spikelet (%)	Grain yield (t/ha)	Panicle per sq.m.	Per Panicle: No. of filled spikelet	Per Panicle: Filled spikelet (%)	
D1. 15x20cm (33.33 hills/m^2)	1.00	219	57	73	1.16	172	77	79	2.16	221	79	86	1.44
D2. 20x20cm (25.0 hills/m^2)	1.35	179	67	79	1.24	147	81	83	1.97	188	77	90	1.52
D3. 30x20cm (16.67 hills/m^2)	1.85	146	80	81	1.47	125	85	79	2.13	176	100	91	1.72
D4. 40x20cm (12.5 hills/m^2)	1.33	111	100	85	1.36	108	97	89	1.97	140	99	90	1.63
MEAN	1.35				1.31				2.06				

L.S.D. (P = 0.05) for Density x Variety : 0.17 t/ha

Effect of Agronomic Practices on Upland Rice Yield during the Second Wet Season at Bouake (long term package evaluation studies)

The objective of this trial was to determine the contribution of various agronomic practices to upland rice yield in different ecologies (monomodal short savannah, monomodal long forest, bimodal savannah, etc.).

The factors included in the field experiment were: seeding method (broadcast and line drilling at the rate of 80 kg seeds/ha), adequate fertilizer (60, 40, 40 Kg N, P_2O_5 and K_2O/ha), soil amendment by Dolomite (1.5 t/ha), weeding, insect control (Furadan 3G at 1.2 Kg a.i./ha) and straw mulch (6.0 t/ha). The complete package included all the above factors and the rest of the treatments lacked one of the factors. IAC 164 was the variety used.

The highest yield was obtained with the complete package, and the lowest with the traditional method (Table 10). Among the factors investigated, absence of dolomite caused highest yield reduction (37%) followed by no weeding, (32%), no mulch (26%), no NPK (22%), no insect control (20%) and broadcast seeding (19%).

Effect of Mechanical Cultivation on Weed Infestation

Weed infestation as well as rainfall insecurity constitute constraints which can bring crops to a complete failure. Weeds are often considered as a traditional constraint to the small scale farmers, but weed infestation can also discourage mechanized farmers, notwithstanding herbicide application. Weeds can appear soon after seeding and many man-days must be spent for cleaning the field, costing sometimes up to the value of one ton of rice.

Foro-Foro (CIMA farm at 30 Kms from Bouake) is representative of such mechanized farms in the region. Upland rice cultivation has been hampered seriously by weed infestation. In 1986, it was decided, through a collaborative programme between WARDA and CIMA (Centre Ivoirien pour le Machinisme Agricole) to improve mechanized upland rice cultivation by trying new methods initiated by the Bouake Station mechanization expert.

In this trial, two tillages were performed before ploughing in order to destroy the first generation of weeds by the first tillage and allow the second generation to germinate and be destroyed by the second tillage. Ploughing will eliminate a third generation of weeds.

Table 10: Effect of agronomic practices on rice yield and drought stresses during the second wet season at Bouake (1986).

Agronomic Practices	Grain Yield	Yield Reduction from CP		Drought stresses
	(Kg/ha)	Kg/ha	%	(79 DAS)
1. Complete Package (CP)	1608 a	-	-	3.2
2. CP - Line Sowing	1304 b	304	19	3.3
3. CP - Insect Control	1279 b	329	20	3.1
4. CP - NPK	1250 bc	358	22	2.4
5. CP - Straw	1196 bc	412	26	4.2
6. CP - Weed Control	1090 cd	518	32	3.6
7. CP - Dolomite	1019 d	589	37	3.5
8. Traditional Method*	752 e	856	53	1.9

*Traditional method includes : - broadcasting (30 Kg seeds/ha)
- one hand weeding
- no NPK
- no dolomite
- no insecticide
- no mulch

After ploughing, seed bed preparation using one or two harrowing completed the weed control.

Twenty hectares were seeded with upland rice with a view to comparing disc-harrow and tine cultivation but, because of lack of spare parts, only disc-harrows were used. (Tine cultivation does not pulverise the soil, prevents erosion and compaction, and pulls out some weed rhizomes such as Imperata).

In order to evaluate the efficiency of the 1986 operations, a comparison was made with 1985 in terms of costs and yield, and it was found that:

- The 1986 average mechanical operation costs were lower than in 1985. The main reason is that the 1986 operations were conducted at the right time and faster.
- The hand weeding costs were about 17.000 F.CFA lower than in 1985.
- Yields were higher in 1986 than in 1985 despite the drought that occurred in 1986.

The programme is to be pursued in 1987 and 1988 in order to try to improve the efficiency of the operations.

SOIL STUDY AND MANAGEMENT

Chemical analysis of upland rice soils from the farmers fields in Cote d'Ivoire were undertaken in 1986. Table 11 illustrates the results of the analyses. In general, soils of various sites visited in Cote d'Ivoire and Ghana are very heterogeneous. This is expressed in the fields by phosphorus, nitrogen, iron deficiencies, manganese or aluminium toxicity and water stress on rice crop.

Soil Characterization at Foro-Foro CIMA Farm

Foro-Foro farm is located at 30 Km north of Bouake in a savannah zone.

According to four "toposequences", a detailed description of soil profiles of the farm was undertaken. Soil samples were taken according to strata for analysis. Only morphological characters observed on the field of some of the sites are

discussd here. Figures 4 and 5 illustrate the results obtained. The soils are characterized by the following profiles:

1. A horizon partly or completely indurated, compact, slightly porous or permeable. This horizon is Located at variable depth (35 to 110 cm) and plays an important role in water infiltration. During water stress periods and when the horizon is located at 35-50 cm deep, rice will suffer from lack of water. (profiles F2, F3, F4, F5, F6 in Fig.4).

2. A deep humid horizon located in a weathering zone. This horizon is clayey and is very important during water stress periods as water can go up from this horizon by capillary movement to supply the plant.

3. A profile with iron stone gravels, quartz stones, rock stones, granite stones all covered by clay and silt. These profiles are sometimes friable and roots can go through deeply.

4. A horizon with light organic matter (profile F1 in Fig.4) or good organic matter content (F5, F7, F8 in Figs 4 and 5).

Table 11: Chemical analysis of upland rice soils from farmers fields in Cote d'Ivoire

	Soils	pH		A + L	M.O	N	C/N	P		Ca	Mg	K	Na	S	T	Y	Al.exch
		Water	KCl	%	%	Total %		Total	assi.	meq/ 100	meq/ 100	meq/ 100	meq/ 100	meq/ 100	meq/ 100	meq/ 100 S/T	meq/ 100
FORO-FORO	I43	6.3	5.4	24.0	1.44	0.45	18.6	175	14	1.8	1.16	0.26	0.02	3.24	4.2	77.14	-
	II43	5.9	5.1	20.75	1.93	0.86	13.0	309	32	1.70	1.10	0.19	0.02	3.01	3.8	79.21	-
	VI46	6.2	5.2	12.25	1.08	0.49	12.8	204	17	1.70	1.08	0.19	0.01	2.98	4.0	74.5	-
BOUNDIALI	KT CP3-4	6.1	4.9	35.55	1.93	0.93	12.0	360	27	1.80	1.00	1.25	0.02	3.07	4.0	76.75	-
	CT CP3-6	8.2	7.5	46	2.17	1.02	12.4	482	36	7.5	2.42	0.62	0.02	10.55	9.9	100	-
	TN 120	8.2	7.5	42.40	2.52	0.99	14.7	299	17	6.9	0.69	0.36	0.01	7.96	7.7	100	-
ODIENNE	M.B	5.9	4.8	31.28	1.63	0.82	18.2	198	15	1.20	0.84	0.28	0.02	2.34	4.5	52	-
	P.O	5.9	4.8	26.13	1.14	0.59	11.1	100	10	1.40	0.92	0.24	0.02	2.58	3.7	69.7	-
	DY	5.8	4.6	13.40	0.51	0.18	16	71	8	0.75	0.29	0.10	0.01	1.15	3.0	38.33	0.12
TOUBA	M.D	4.4	3.9	31.28	1.93	0.78	14.4	129	13	0.30	0.14	0.10	0.01	0.55	4.8	11.4	2.00
MAN	P.O	4.4	3.9	31.15	2.13	1.04	11.9	130	10	0.30	0.14	0.09	0.01	0.54	4.7	11.5	1.95
TOMBOKRO	T2	7.9	7.3	18.43	1.25	0.57	12.8	186	38	4.30	1.08	0.40	0.02	5.8	5.6	100	-
	T1	7.8	7.3	21.80	1.03	0.57	10.5	153	23	4.6	1.08	0.29	0.01	5.98	5.6	100	-

Effect of Mechanical Cultivation on Water Retention Capacity of the Soil

The ability of the soil to store water from rainfall in order to restitute it when needed (e.g. during drought stresses) is very important in upland rice cultivation. Most ferralitic soils present a hard pan at 25-30cm from the top surface as a consequence of continuous ploughing and harrowing at the same depth. Therefore, while light rainfall (15-20 mm) would penetrate slowly, heavy rains (40-60 mm) do not penetrate but rather create run off and erosion, preventing water to be stored in the soil profile.

The objective of this study was to determine the effect of a subsoiler breaking the hard pan. The subsoiler's strong blade can penetrate the soil profile. Pluviometers were used to record daily and monthly rainfall. The subsoiling was conducted at Foro-Foro (30 kms from Bouake) using a 75 HP tractor and subsoiler.

The soil was very dry but loose because fields had previously been cultivated in 1985 with yams.

Tables 12, 13 and 14 indicate the drought periods and the balance between the rainfall and the water needs of the varieties during the growing season. It can be seen that negative balances were recorded for all the varieties from panicle initiation to maturity. Despite this situation, the mean yield for IAC 164 was 2.5 t/ha (range 1.8 t/ha to 3.2 t/ha) with subsoiling compared to 1.6 t/ha (range 1.5 to 1.8 t/ha) without subsoiling. It appears that subsoiling increased yield significantly by improving the water retention capacity of the soil.

LEGEND OF SOIL PROFILE DIAGRAMS

- Horizon with organic matter and ferruginous stones.
- Horizon with little organic matter and ferruginous concretions.
- Sandy horizon with ferruginous stones small angular rock-crystal.
- Horizon more or less indurated with ferruginous stones and rock-crystal.
- Ferruginous elements with stont and drift sand.
- Clayey horizon with blocs and boulder rock-crystal.
- Clayey horizon with small rock-crystal and micas
- Carapce
- Ferruginous cuirass

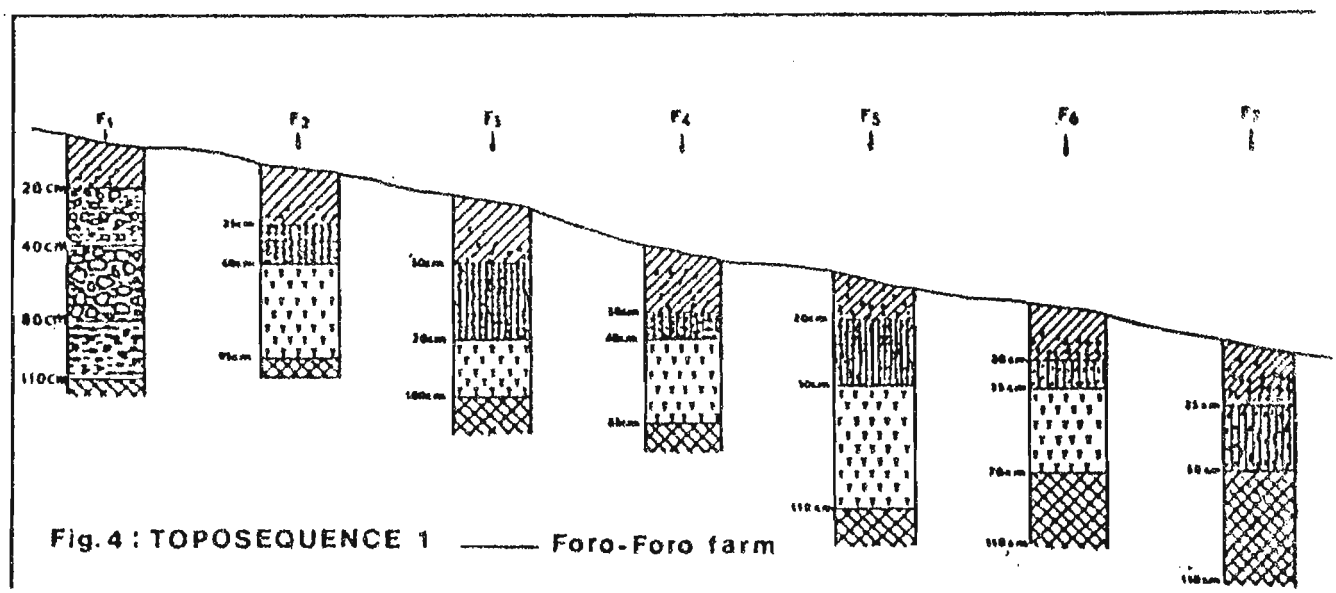


Fig. 4 : TOPOSEQUENCE 1 ——— Foro-Foro farm

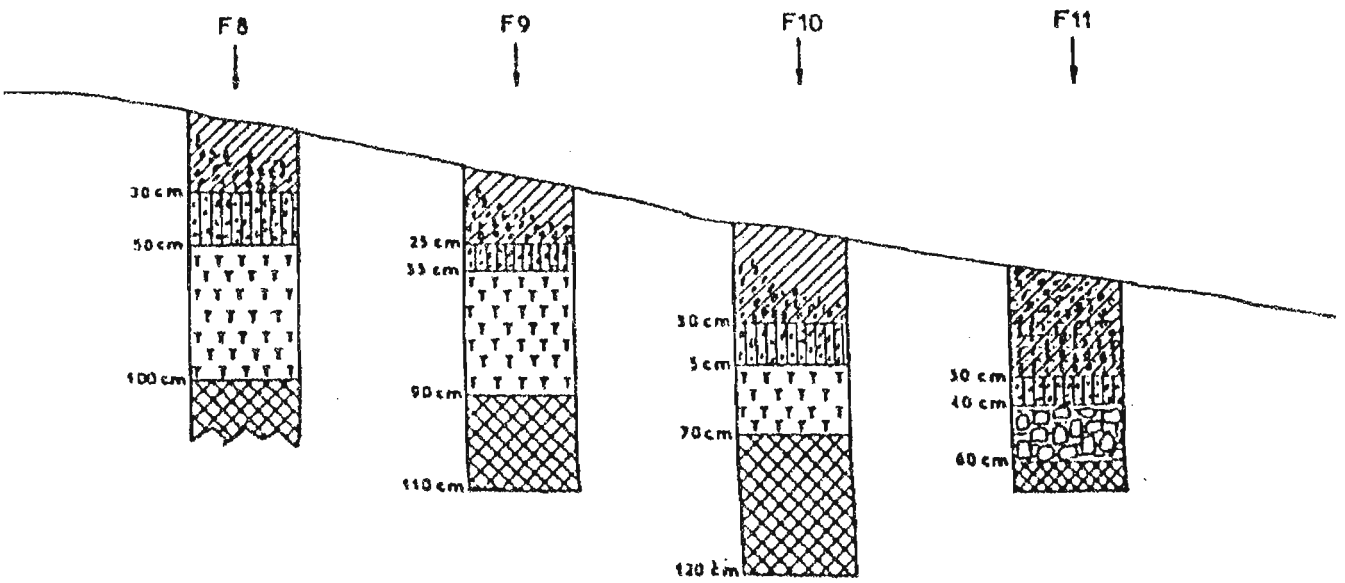


Fig. 5: TOPOSEQUENCE 11 ——— Foro-Foro farm

Table 12: Drought periods during growing season, 1986.

Drought periods		
Period	Duration	Rainfall
June 14 - July 3	20 days	22 mm
July 4 - July 20	16 days	7 mm
July 22 - July 30	9 days	0 mm
Aug. 6 - Aug. 30	25 days	6 mm

Table 13: Evaluation of the Balance between Water Needs and Rainfall

Moderate Needs Period (from tillering to panicle initiation)							
Variety	Date of seeding	Tillering stage	Panicle initiation	Rainfall mm	Needs mm	Balance mm	Satisfaction rate
IRAT 104	25/5	24/6	17/8	357	243	+114	147%
IRAT 170	3/6	3/7	11/8	207	189	+18	110%
IDSA 6_1	2/6	2/7	10/8	210	189	-21	111%
IDSA 6_2	4/6	4/7	12/8	170	189	-19	90%
IRAT 144	10/7	4/8	28/8	44	106	-62	41%
IAC 164_1	20/6	14/7	7/8	151	106	+45	142%
IAC 164_2	1/7	24/7	17/8	63	106	-43	60%
IAC 164_3	16/7	10/8	3/9	37	106	-69	35%

Table 14: Evaluation of the Balance between water needs and rainfall

Important Needs Period (from panicle initiation to maturing stage)							
Variety	Date of seeding	Panicle initia-	Maturing stage	Rain-fall mm	Needs mm	Balance mm	Satisfac-tion rate
IRAT 104	25/5	17/8	15/10	246	383	-137	64%
IRAT 170	3/6	11/8	1/10	215	338	-123	63%
IDSA 6_1	2/6	10/8	30/9	218	338	-120	64%
IDSA 6_2	4/6	12/8	2/10	233	338	-105	68%
IRAT 144	10/7	28/8	19/10	246	338	-92	72%
IAC 164_1	20/6	7/8	28/9	198	338	-140	58%
IAC 164_2	1/7	17/8	8/10	227	338	-111	67%
IAC 164_3	16/7	3/9	25/10	166	338	-172	49%

TECHNOLOGY ASSESSMENT AND TRANSFER

The Technology Assessment and Transfer (TAT) programme at Bouake was started in 1983. From preliminary analyses of constraints to upland rice production in West Africa, it became clear that the development of improved varieties should receive top research priority through two main approaches: a breeding programme, and evaluation of existing varieties in farmers' fields (verification and adaptive trials).

Since 1983 a number of existing improved varieties have been evaluated for yield and socio-economic suitability in Côte d'Ivoire. Of all the varieties tested, IAC 164 and IDSA 6 have now reached a stage where they can be transferred to farmers. In fact, national rice research and extension institutions in Côte d'Ivoire have collectively declared IAC 164 a standard check for all research and extension purposes. From their impact in Cote d'Ivoire, IAC 164 and IDSA 6 were introduced and tested in Ghana during the 1986 cropping season and are expected to be tested in Sierra Leone during 1987. Thus, the objective of the 1986 TAT programme was to continue constraints analysis and the evaluation of existing varieties in Cote d'Ivoire, Ghana and Sierra Leone.

Preliminary surveys on constraints analysis program were carried out in Cote d'Ivoire, Sierra Leone and Ghana. Data will be reported in future reports after analysis

On-farm Trials

Verification Trials

In 1986, verification trials were conducted in Cote d'Ivoire and Ghana. In Cote d'Ivoire, the trials were a continuation of the 1985 work while in Ghana they were conducted for the first time.

There were 40 trials in Cote d'Ivoire and 22 in Ghana conducted on $100m^2$ plots in a randomized block design in which different farmers in a village were considered as a block. In Cote d'Ivoire, 5 varieties: IAC 164, IDSA 6, IRAT 170, Dourado precoce, and Iguape Cateto were compared with local varieties with and without 75 kg urea/ha in each of the following rainfall zones: bimodal forest (1100 - 1400 mm), monomodal long forest (1600 - 1800 mm), monomodal long savannah (1300 - 1500 mm), and monomodal short savannah (1200 - 1400 mm). In Ghana, traditional varieties were compared with IAC 164, IDSA 6, the latter two varieties were proposed by the collaborating institution, Nyankpala Agricultural Experimental Station (NAES).

Yield performance in Cote d'Ivoire revealed that the rice grain yield for the 40 trials ranged from zero to 2.3 t/ha. These yields are lower than those obtained in the past two years mainly due to drought in 1986 in the whole country generally. In areas such as Man, yields were reduced to less than half of the expected yield and in Gagnoa, about 80% of the trials were lost (Table 15).

As can be seen in Table 15, generally speaking, IAC 164 and IDSA 6 performed better than Dourado precoce, Iguape, IRAT 170, and the local checks but IAC 164 was the best of all the varieties. IAC 164 has now been tested for the third consecutive year and IDSA 6 for the second consecutive year. The fact that these varieties perform well in both good (1985) and bad years (1986) indicates favorable yield stability.

Table 15: Yield performance of six varieties with and without fertilizers

Ecology	Locality	Variety, Package and Rice Grain Yield (ton /ha)												
		IAC 164		Dourado P.		IDSA 6		IRAT 170		Iguape C.		Local C.		Mean
		LI	HI	LI	HI	LI	HI	LI	HI	LI	HI	LI	HI	
Bimodal forest (1100-1400mm)	Kregbe (Bongouanou)	1.4	1.6	0.8	1.5	1.4	2.3	1.2	1.9	1.3	1.7	1.0	1.8	1.5
	Dobouo (Gagnoa)	1.3	1.7	0.8	1.0	-	-	-	-	-	-	-	-	1.2
	Grobonoudan (San P.)	1.2	1.4	1.0	1.2	0.8	1.0	0.5	0.8	0.6	0.7	0.6	0.8	0.8
	Mean	1.3	1.6	0.9	1.2	1.1	1.7	0.9	1.4	1.0	1.1	0.8	1.3	1.2
Monomodal long forest (1600-1800mm)	Gblapleu (Guiglo)	1.1	1.2	0.7	0.6	1.2	0.9	0.8	0.5	1.2	0.7	0.5	0.8	0.8
	Blole (Man)	0.4	0.5	0.3	0.4	0.6	0.6	0.4	0.6	0.6	0.5	1.4	1.3	0.6
	Mahapleu (Danane)	1.5	0.8	1.3	0.7	1.6	1.3	1.4	1.2	1.4	1.2	-	1.3	1.2
	Mean	1.0	0.8	0.6	0.6	1.1	0.9	0.9	0.8	1.1	0.8	1.0	0.8	0.8
Monomodal long savannah (1300-1500mm)	Mandougou (Touba)	0.8	1.7	0.3	0.5	1.2	1.0	0.8	0.8	0.8	0.5	-	-	0.8
	Seguelon (Odienne)	0.3	-	0.3	-	1.2	1.7	0.9	1.0	1.0	1.2	0.6	1.4	0.9
	Mean	0.6	1.7	0.3	0.5	1.2	1.4	0.9	0.9	0.9	0.9	0.6	1.4	0.8
Monomodal short savannah (1200-1400mm)	Ponondougou (Boundiali)	1.1	1.8	1.2	1.3	1.2	1.2	1.5	1.1	0.9	1.4	0.9	0.9	1.2

LI = Low inputs (variety only)

HI = High inputs (variety + 75 kg urea/ha)

With regard to varietal fertilizer response, there was a better response to nitrogen in the bimodal forest zone and monomodal short savannah than in the monomodal long savannah. This may have been due to leaching by the prolonged rainfall. Again, IAC 164 and IDSA 6 showed better response than Dourado precose, Iguape cateto and IRAT 170.

Weed problems, disease incidence and insect problems on the on-farm trials were noted. From the observations, the weeds of greatest concern in Cote d'Ivoire include: Eupatorium odoratum L., tree regrowth, Rottboellia exaltata L.F., Euphorbia heterophylla L., Digitaria spp., Imperata cylidrica L. P. Beauv. Cyperus rotundus L. , Brachiaria spp., Panicum spp. and Pennisetum spp. Species of Striga have been observed in the north of the country, particularly in rice fields mixed with sorghum and millet.

The rice varieties, IAC 164 and IDSA 6 still maintained their good resistance to leaf blast, neck blast, false smut and panicle discolouration irrespective of the location.

Insect species collected at different sites were similar to those found in Bouake and Toumbokro but again there were variations in relative abundance. A few species were rather specific to certain areas. Locris maculata was abundant in Guiglo and Danane, both areas of monomodal long rainfall in the forest zone. They were present to a lesser extent at Seguelon and Mandougou in the savannah zone, but absent at the other sites. Similarly, Epilachna similis was more abundant at Mandougou, Man and Seguelon but virtually absent at Ponondougou and Guiglo.

Stem borers were also found at all the sites. As usual, Maliarpha separatella, Chilo zacconius and Sesamia calamistis were lepidopterous species. Generally, the forest zones had more Sesamia and Chilo than the savannah zones where Maliarpha tended to dominate. However, the low sample size obtained in some sites necessitate caution in generalization. This information needs to be reconfirmed.

Among the six varieties used in the verification trials, the traditional variety (Azi) appeared to be less susceptible to stem borers. Dourado Precoce was the most susceptible.

Adaptive Trials

The 1986 adaptive trials were conducted in Cote d'Ivoire only in continuation of the 1985 programme. There were 42 farmer-managed trials conducted on 1000m^2 plots using a randomized block design in which each farmer was considered as a replication. At each site, IAC 164, or IDSA 6, was tested against the local variety under 4 different packages:

CP1 - Variety IAC 164 alone

CP2 - Variety IAC 164 + 75 kg urea/ha

CP3 - Variety IAC 164 or IDSA 6 + animal traction soil preparation
+ 75 kg urea/ha + 150 kg NPK (10-18-18)/HA
+ Oxadiazon 1.0 kg a.i./ha

CP4 - Variety IAC 164 or IDSA 6 + traction soil preparation
+ 75 kg urea/ha + 150 kg NPK (10-18-18)/ha
+ Oxadiazon 1.0 kg a.i./ha.

At each site agronomic and socio-economic data were collected.

The results (Table 16) show that the variety IAC 164 by far outyielded local checks with and without the improved technological package in 4 out of 42 locations. The exception, in which zero yields and a yield decrease of 42% over the local checks were recorded, was due to drought to which the local checks showed remarkable tolerance.

When tested alone (CP1), IAC 164 had a yield increase of 37-136% with an average of 41%. When 75 kg urea/ha was added (CP2), IAC 164 out-yielded local checks at all the 14 sites with a yield increase of 17-100% and an average of 44%. What is more, IAC 164 with urea raised its potential yield increase from 136 to 155%.

Animal traction plus fertilizer and herbicide application (CP3) further improved the performance of IAC 164 and raised its potential yield increase from 136 to 177% . Tractor soil preparation did not improve yields of IAC 164 above animal traction.

Table 16: Yield response to different management packages

Locality	CP1 /1				CP2				CP3				CP4			
	Variety and mean yield ton/ha		Mean yield increase		Variety and mean yield ton/ha		Mean yield increase		Variety and mean yield ton/ha		Mean yield increase		Variety and mean yield ton/ha		Mean yield increase	
	IAC 164	LC2	ton/ha	%	IAC 164	LC	ton/ha	%	IAC 164	LC	ton/ha	%	IAC 164	LC	ton/ha	%
Kregbe (Bongouanou)	2.6	1.1	1.5	136	2.8	2.4	0.4	17								
Dobouo (Gagnoa)	2.2	1.6	0.6	37	1.8	1.5	0.3	20								
Gblapleu (Buiglo)	1.7	1.7	0	0	2.2	1.7	0.5	29								
Biole (Man)	0.4	0.7	-0.3	-42	1.0	0.5	0.5	100								
Ponondougou (Boundiali)	2.3	1.3	1.0	77	2.5	1.6	0.9	56	3.6	2.6	1.0	38				
Mandougou (Touba)									2.6	2.3	0.3	13	2.7	2.5	0.2	8
Seguelon 2/ (Odienne)									2.0	1.7	0.3	18	2.6	1.8	0.8	44
Mean	1.8	1.3	0.6	42	2.1	1.6	0.5	44	2.7	2.2	0.5	23	2.7	2.1	0.5	26

1. See next page
2. LC = Local Check
3. Variety IDSA 6 was used instead of IAC 164

The variety IDAS 6 was tested at one locality involving 2 sites only under CP3 and CP4. Yields of 2.0 - 2.6 t/ha were, however obtained with a yield increase of 18-44% over the local checks using the same package management.

Using mean yield for each package (Table 16), the performance of the packages can be summarized as follows:

- Yield increase due to IAC 164 alone = 0.5 t/ha or 38% (1.8 vs 1.3)
- Yield increase due to urea alone = 0.3 t/ha or 23% (1.6 vs 1.3).
- Yield increase due to IAC 164 + 75 kg urea = 0.8 t/ha or 62% (2,1 vs 1.3).
- Yield increase due IAC 164 + 75 kg urea + 150 kg NPK +Oxadiazon 1.0 kg a.i./ha = 2.3 t/ha or 177% (3.6 vs 1.3 for one location only).
- Yield increase due to IDSA
  - in CP3 = 0.2 t/ha or 18% (2.0 vs 1.7)
  - in 0.8 t/ha or 44% (2.6 vs 1.8)

REGIONAL MANGROVE SWAMP RICE RESEARCH STATION, ROKUPR (SIERRA LEONE)

I. INTRODUCTION

Development of technology for increasing production and income of resource-poor mangrove swamp rice farmers in West Africa is the major objective of the Regional Mangrove Swamp Rice Research Station. Over 100,000 farm families in the region are dependent on rice cultivation in mangrove swamps for their livelihood. About 200,000 hectares of mangrove and associated swamps are cultivated. Rice production is constrained by salinity, acidity, nutrient deficiencies, mineral toxicities, diseases and pests as well as limited labour, inadequate extension education and unavailability of inputs including credit facilities.

In 1986, research activities continued to focus on the generation of technology packages that are cheap, effective and easily adaptable to the management capability of the mangrove swamp rice farmer.

This section of the Annual Report provides concise research results in varietal improvement, crop and soil management, pest management and on-farm adaptive trials.

II. VARIETAL IMPROVEMENT

As in the previous years the 1986 varietal improvement program focused on improving lines and population for the broad spectrum mangrove swamp conditions such as soil stresses (salinity, acidity, iron toxicity) and pests including diseases.

A. GERMPLASM EVALUATION AND UTILIZATION

1. Collection and introduction: Eighteen accessions were collected in 1986, 9 each from Guinea-Bissau and the Gambia. This brought the number of accessions to 754 traditional varieties collected from the region. The collection also included 1kg sample of 1040 introduced varieties that have been tested and are adaptable to the mangrove swamp conditions in the region.

Eighty-seven accessions were purified and characterized for 48 morphological and agronomic characteristics. A further 208 accessions were regenerated.

2. Screening for tolerance to soil stresses

Multiple tolerance to soil stresses: Merr 108A, Bathurst 32, Foday Yoreh 250 and Ginsa Killing have been identified as new sources with multiple tolerance to various soil stresses and were utilized as parents in crosses to develop varieties with improved tolerance. Several promising advanced lines including WAR 81-2-1-3, WAR 50-30-1-3-1, WAR 74-23-2-2-B-2, WAR 79-4-R-1-2-1, WAR 91-2-4-1 and WAR 98-6-19-1 which have multiple tolerance to soil stresses were identified this season and will be tested in various trials in 1987.

3. Screening for resistance to pests

Seedling blast: One hundred and fifty rice accessions along with standard mangrove swamp rice cultivars and blast differential varieties were screened for resistance to seedling blast at Rokupr and Rotifunk in Sierra Leone. The following accessions were completely free of the disease, namely, IR52-17-2-2-1, IR 14753-120-3, IR 25915-41-3-1. N.N 72-2, WAR 38-23-1-3-1, WAR 49-54-1-2-1, WAR 52-10-2-2-2 and WAR 74-1-2-3-1.

Rice Yellow Mottle Virus (RYMV): Two hundred rice accessions were screened for resistance to RYMV at the seedling growth stage in a rainfed upland/nursery at Rokupr. Among the resistant or tolerant varieties observed were LAC 23, ITA 116, Angkata, ROK 16, Kpenyei (Red), WAR 38-46-1-2 and WAR 39-50-2-3.

Crab damage: Seventy-six varieties rated as having resistance to crab damage from previous screenhouse studies were tested in the field with a fairly high crab population. Results indicated that the traditional varieties, Pa Bayoh 246, Damalai 247A, Damalai 247B and Ralontho 265B were resistant to crab damage.

4. Observational trials

Introductions comprising lines from IRRI-IRTP nurseries were screened as follows :

IRON: A total of 366 entries were tested in an associated swamp which is subject to shallow flooding three to four months during the rainy season. Sixty-six of the entries were

selected for further studies. The entries P2060-F4-11-4, IR28183-2-2-1-1, B3981C-pn-165-2-1, BW278-2-Pn-186-Kp-2 and BW293-2 scored higher than WAR 1 and ROK 5 (check varieties) and ranked in the top five entries on the basis of grain yield and phenotypic acceptability.

ITPRON : A total of 63 entries with ROK 5 and ROK 10 as check varieties were tested in a deep flooded tidal site at Rokupr. Ten varieties with a plant height range from 90-130cm and a growth duration range from 159-176 days outyielded ROK 5 and ROK 10. These were selected for inclusion in the long duration observational yield trial (OYT) next season. The top five varieties included IR13146-45-2, IR31238-474-3-P4, BRB20-3B-17, B27916-Mr-196-2-3-1-8kp-3 and GH 147m (B2489d-pn-1-76-7-m).

IRRSWON : Two hundred and three entries with ROK 5 and CP 4 as check varieties were tested in a shallow flooded tidal site at Rokupr. Only ten varieties which gave higher grain yield and better phenotypic acceptability scores than the check varieties were selected for further studies. The selections ranged in duration from 159 to 178 days and with a plant height range of 82 to 124cm. The top five varieties, on the basis of grain yield included R114-2-1-1-1 (IET 9171), IR9884-54-3-IE-PI, CN 540, IR26724-246-1-1 and BW295-4.

Acid Lowland Soils Screening Set: Ninety entries were tested on a problem tidal site with low pH of 3.8. Twenty-eight entries were selected for further studies. The best entries, based on their reaction to soil problem and ability to withstand tidal flooding were BR51-46-5, IR28222-9-2-2-22, B21496-PN-26-1-1 and IR2153-26-3-5-6.

IRSATON: The salinity screening set comprising 90 entries were tested at Balancera, a salt affected site in Northwest Sierra Leone. Based on their reaction to salinity during the vegetative phase and their grain yield, 17 entries were selected for further studies. The best four test entries were IR19392-33-3, IR 24, IR1966-150-2-2-2-1 and IR58.

B. BREEDING

New crosses: Thirty-eight new crosses were made to incorporate desirable characteristics (e.g. suitable agronomic characters, tolerance to major soil stresses) into improved varieties. A number of multiple crosses were made to enlarge genetic variability in the breeding populations. Also, back crosses were made to improve certain characteristics such as blast resistance of some recommended varieties and promising lines.

Segregating Populations: Breeding nurseries contained over 300 segregating lines on Station and over 500 F4-F6 population on off-station problem sites. Over 1,200 plant selections were made and advanced to the next generation.

C. VARIETAL TRIALS

Introduced varieties/advanced lines selected from previous screening activities were further tested in a number of Observational Yield Trials and replicated yield trials (RYTs) at the Rokupr Station.

Short Duration OYT: Seventy-four varieties and 11 Rokupr bred advanced lines were tested in an associated mangrove swamp site at Rokupr. The two best varieties, IR15529-26-1-1-2-1 and IR17525-7-19-1-3-3-1 outyielded IR10781-143-2-3 (check variety by 15 and 8 percent, respectively. The check variety yielded 4166 kg/ha.

The duration and plant height of the selected lines ranged from 119 to 140 days and from 72 to 135cm, respectively. Selections with intermediate plant height between 100cm and 130cm have potential for use in the deep flooded swamps of The Gambia, Guinea-Bissau and Senegal where the salt-free or minimum salt period is about four months.

Medium Duration OYT: Sixty selections from 1985 OTs were tested against ROK 5 in the tidal mangrove swamp at Rokupr. The test varieties ranged in duration from 135 to 158 days. ROK 5 yielded 2164 kg/ha on average. Highest grain yield obtained from test varieties was 3688 kg/ha. Only three Rokupr bred advanced lines, WAR 72-1-1-1-4, WAR 72-1-1-1-1 and WAR 87-10-2-2-7 which outyielded ROK 5 by margins of 17, 6 and 4 percent, respectively, were selected for further testing. The plant heights of these selections ranged from 84 to 120 cm.

Long Duration OYT: In all 72 introduced varieties and 8 Rokupr bred advanced lines were tested against ROK 10 at a site subject to deep tidal flooding. The best six lines outyielded the best ROK 10 plots by margins ranging from 53 to 102 percent. The duration and plant height of the selections ranged from 177 to 196 days and from 74 to 125cm, respectively. These varieties could provide alternatives for cultivation in some mangrove swamps of Sierra Leone and Guinea with salt free period of over five months.

OYT of F4 Lines: Ninety-seven lines from four crosses were tested against ROK 5 and ROK 10 at a tidal problem site with an initial low pH of 3.8. Table 1 shows the performance of selections from OYT of F4 lines tested under advanced tidal mangrove swamps condition at Rokupr. The selection gave higher yields and better acidity tolerance scores than the check varieties.

Table 1 Performance of selections from observational yield trial of F4 lines tested under adverse tidal mangrove swamp conditions (acid sulphate soils) at Rokupr.

Cross	No. of entry	No. of selection	Acid Sulphate 2/ tolerance	Grain Yield (kg/ha)	Growth duration (days)	Plant height (cm)
Sigadis/IR9575-Sel	19	9	2.4	3611	176	115
IR 3259-P5-1/7-Canuto	34	19	3.6	2682	165	97
BG 90-2/IR4595-1-4-15	34	25	3.6	2687	151	98
Djukema/Raminad Str. 3	10	5	3.8	2576	176	103
ROK 5 1/						
(Mean of 6 plots)	-	-	3.8	1933	155	128
ROK 10 1/						
(Mean of 6 plots)	-	-	4.8	1817	196	130

1/ Check variety
2/ Scale 1-9: 1= Good, 9 = Poor
(Mean of scores obtained at 4 and 8 weeks after transplanting).

Associated Mangrove Swamp RYTs: Two RYTs of short and medium duration were conducted in the associated swamp at Rokupr.

In the short duration (120-135 days) associated swamp trial, 12 introduced varieties and three advanced lines were tested against ROK 5, the standard check variety. The top variety BG 380-2 advanced from 1985 OYT was superior to ROK 5 in grain yield. A new Rokupr bred advanced line, WAR 49-5-1-3-1 ranked third with an average yield of 3117 kg/ha. The earliness of the varieties coupled with their intermediate stature, with an average plant height of 101cm, make them potential materials for use in empoldered mangrove swamps with less than four months of salt-free period as obtained in the northern part of the region. BG 380-2 and WAR 49-5-1-3-1 exhibited extremely high tillering ability (308 and 302 tillers/m2, respectively).

In the medium duration (135-155 days) associated swamp trial, 14 varieties were compared with WAR 1 and ROK 5. The trial was conducted in a fertile site in the seepage zone. Twelve of the entries had grain yield in excess of 4000 kg/ha. Differences in grain yield observed among the varieties were not significant although nine new entries advanced from 1985 OYT gave higher grain yield than the check varieties (Table 2). WAR 77-3-2-2 gave the highest yield of 4989 kg/ha.

Tidal Mangrove Swamp RYTs: One medium and two sets of long duration trials were carried out in the tidal mangrove swamp at Rokupr.

Out of the 13 entries in the medium duration RYT, only two varieties, WAR 1 and Rohyb 4-WAR-1-3-B-2 outyielded ROK 5 (check variety).

In the first category of long duration (155-180 days) RYT, the varieties, WAR 44-50-4-1, Rohyb 6 WAR-6-2-B-2, WAR 44-17-5-3, and IR 13429-R-WAR-1 performed better than Kuatik Kundur, the check variety (Table 2).

In the second category of long duration (180-200 days) RYT, three varieties, Maung Nyo B24-92, Gbassin (a local selection) and Raden Jawa outyielded CP 4 and ROK 10. The check variety Maung Nyo B24-92 (200 days) produced a grain yield of 4110 kg/ha as compared to 3662 and 3615 kg/ha from CP 4 and ROK 10, respectively.

Table 2. Performance of the top 4 entries and their check varieties in medium and long duration RYTs.

Variety	Grain yield (kg/ha)	Growth Duration (days)	Plant height (cm)	Effective tillers/m2	100 grain weight (g)
Medium Duration (175-155 days) 1/					
WAR 77-3-2-2	4989	152	130	238	34
RTN 16-2-1-1-1	4812	155	103	217	27
BG 400-1	4736	132	103	247	30
WAR 81-2-1-3-1	4721	155	128	255	25
WAR 1(Rohyb 15) 2/	4204	143	138	221	33
ROK 5 2/	3831	155	144	207	31
Mean of 16 varieties	4229	149	126	230	30
L.S.D. (0.05)	ns	ns	12.37	43.57	2.36
C.V. (%)	17.90	10.45	6.87	12.72	5.46
Long Duration (155-180 days) 3/					
WAR 4450-4-1	2863	174	151	118	20
Rohub 6 WAR-6-2-b-2	2781	166	155	202	29
WAR 44-17-5-3	2772	178	152	161	23
IR 3429-R-WAR-1	2535	169	136	150	26
Kuatik Kundur 2/	2447	168	147	160	23
Mean of 14 varieties	2245	173	145	165	23
L.S.D. (0.05)	484.20	5.33	8.07	46.36	2.45
C.V. (%)	15.15	2.16	3.89	19.60	7.44

1/ Conducted in associated swamp

2/ Check varieties

3/ Conducted in tidal mangrove swamp
(WAR and Rohyb - Rokupr bred advanced lines)

D. OTHER ACTIVITIES OF THE VARIETAL IMPROVEMENT PROGRAM

The program undertakes the multiplication and distribution of seeds. In 1986, 37 recommended and promising varieties/advanced lines were multiplied on about 4 hectares of land at the Station. A total of 540 kg of breeder and 3,600 kg of foundation seeds were produced. Small quantities of breeder and foundation seeds were distributed to national programs in the region for further testing and distribution to farmers. Fifty-five kilograms each of two varieties, Rohyb 6-WAR-6-2-B-2 and Kuatik Kundur were sent to Guinea for further multiplication and distribution to farmers. Thirty kilograms each of foundation seeds of WAR 1, Rohyb 6-WAR-6-2-B-2 and Kuatik Kundur were sent to the Seed Multiplication Project in Sierra Leone for further multiplication. Guinea-Bissau received 10 kg each of WAR 1 and Rohyb 4-WAR-1-3-B-2. Further samples (10-1000g) of approximately 400 varieties/advanced lines were distributed to Stations and other scientists in the region for use as trial materials.

II. SOIL AND CROP MANAGEMENT

Development of methods for improving and sustaining high yields of rice in tidal mangrove and associated swamps continued to be the main thrust of the soil and crop management program.

Soil and crop management trials

Improving the efficiency of N - fertilizer use: The effi-ciency of the injection technique, basal incorporation and 3 split broadcast of prilled urea in improving nitrogen utilization and grain yield of flooded rice were evaluated in a deep flooded non-tidal swamp at Rokupr.

Deep placement of nitrogen in the soil increased grain yield of rice more effectively than three split broadcast method of application (Table 3). The superiority of injection and basal incorporation over broadcast is attributable to greater retention and utilization of the soil incorporated nitrogen by the rice crop. These results confirm results of earlier trials.

Table 3: Grain yield (kg/ha) showing rice (ROK 5) response to methods and levels of nitrogen application under deep flooding in the associated mangrove swamp at Rokupr.

Methods of Application	Grain yield/Nitrogen applied (kg/ha)			
	30	60	90	Mean
3-split broadcast	2006	2406	2552	2311
Injection; 20cm depth	2615	2783	3338	2912
Basal incorporation	2501	2933	3375	2936
Mean	2374	2707	3078	
Control; Without N		1850		

C.V. (%)	13.0
L.S.D. 0.05; for differences between control and treatments	385.0
L.S.D. 0.05; for differences btween treatment means	333.0
L.S.D. 0.05; for differences between levels of applied N	192.0
L.S.D. 0.05; for differences between methods of N application	167.0

Predicting nitrogen status of associated mangrove soils: Available NH^+_4 - N and NO_3 - N were compared in soil samples, air dried or wet (Stored below 4°C for 30 days in air-tight polythene containers) to determine suitable handling/pretreatment procedures of soil samples in the estimation of soil-N.

Marked differences in the values for available NH^+_4 - N and NO_3 - N were obtained from different handling/pretreatment procedures of the soil samples. Soil test values for available NH^+_4 - N were consistently higher in the wet soil than in the air-dried soil (Figure 1). The differences were larger in the 0-10cm soil depth than at lower depths. This is indicative of losses due to N transformation in the soil during the process of drying and could be greatly influenced by the initial moisture content and subsequent period of drying.

Correlation of available nitrogen soil test values with grain yield gave consistenly higher "r" values for wet samples than the air-dried soil samples taken at different depths. This suggests that more reliable estimates of plant available nitrogen in swamps can be obtained by analysis of NH^+_4 - N in wet soil samples. However, routine analysis of large numbers of wet soil samples may be cumbersome. There is also a need for standardisation of such a procedure.

Figure 1. The effect of method of soil samples handling on the available NH^+4 -Nand NO_3 - Nvalues

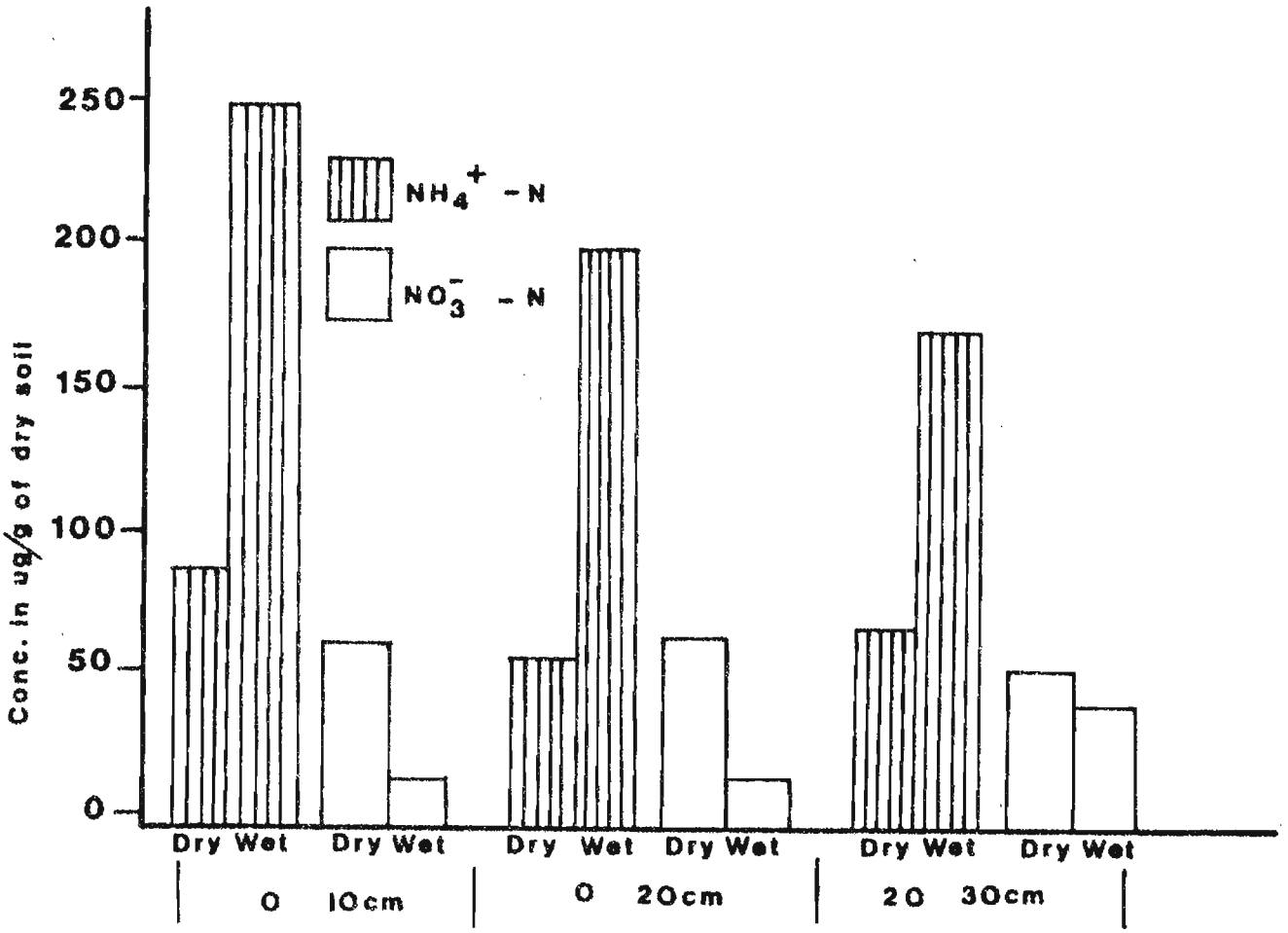


Fig 1. The effect of method of soil sample handling on the available NH_4^+ - N and NO_3^- -N values

Varietal response to nitrogen: The nitrogen response curve of newly developed mangrove swamp rice varieties was determined to facilitate optimum fertilizer recommendations and enhance the potential of the varieties for top performance in different sub-ecologies of the mangrove swamp.

The rice varieties grown differed significantly in response to nitrogen in both tidal and associated mangrove swamp (Figure 2). The high response of the varieties to the initial increment of nitrogen reflects the inherently low soil nitrogen release in the mangrove swamp rice ecologies.

The results suggest that investments in nitrogen fertilizers may be highly profitable in the case of the new Rokupr bred varieties Rohyb 6-WAR-6-2-B-2 grown in tidal mangrove swamps. The variety ROK 11 may not be suited for rice production in the inherently low soil fertility conditions encountered in most associated mangrove swamps.

Figure 2. Grain yield response of varieties to nitrogen in (A) the tidal mangrove and (B) seasonally inundated associated swamps at Rokupr.

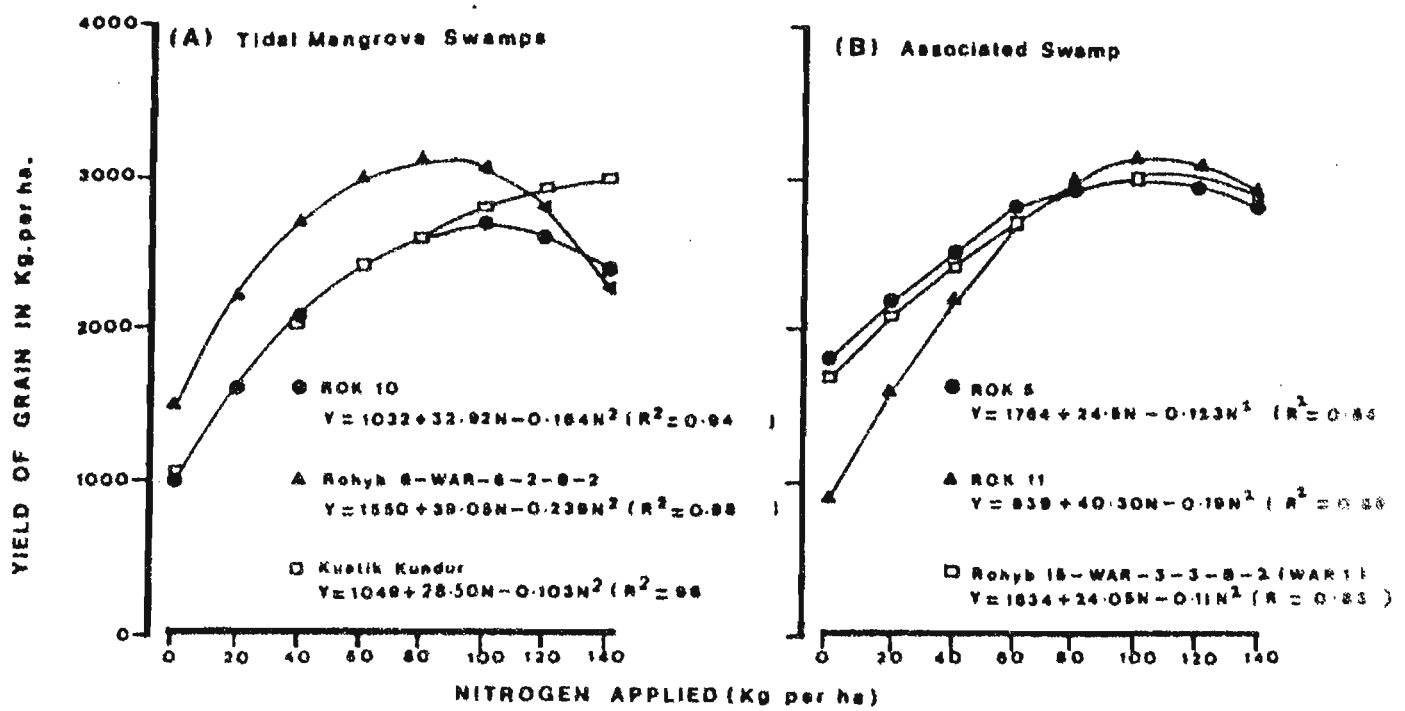


Fig. 2 Grain yield response of varieties to Nitrogen in
(A) The tidal mangrove and
(B) Seasonally inundated associated swamps at Rokupr.

Response to phosphorus: Phosphorus deficiency is the predominant nutritional disorder of rice grown in the seasonally inundated associated mangrove swamps. Performance of the rice crop in this ecology is generally improved with the application of superphosphate. Rice response to the application of rock phosphate materials in tidal mangrove swamps in the past have been inconsistent. A trial was conducted to determine the efficiency of different phosphorus fertilizers and effect of intensive phosphate applications on rice production in associated mangrove swamps.

Average grain yield of rice was higher with the application of single superphosphate than with rock phosphate materials (Table 4). Mineralisation of phosphorus in rock phosphate materials is comparatively slower and may require acidification in some instance. The long term use of rock phosphate materials may be beneficial for rice production in the associated mangrove swamp.

Table 4: Grain yield (kg/ha) showing response of rice to source of phosphorus in the associated mangrove swamp.

Source of phosphorus	Grain yield/phosphorus - P2O5 applied (kg/ha)			
	40	80	120	Mean
Taiba rock phosphate	3741	3182	2800	3274
Matam rock phosphate	3104	2362	2682	2716
Single superphosphate	3263	4023	4054	3780
Mean	3403	3189	3179	
Control - without phosphorus		2804		

C.V. %	24.1
L.S.D. 0.05. for comparison of control with other treatment means	650.8
L.D.S. 0.05. for comparison between sources of phosphorus	779.8
L.S.D. 0.05. for comparison between levels of phosphorus	779.8

Azolla

Methods of Azolla cropping on rice production: Effects of different methods of Azolla cropping on rice production were evaluated in the associated swamp at Rokupr in the last cropping season.

Azolla cultivation was equally effective as urea - N in improving grain yield of rice (Table 5). Under good water control (5-10cm water levels) and initial low level of Azolla inoculation (400g gr. wt./m2) tillering of the rice was not restricted in the Azolla dual crop culture.

Table 5. Some yield components, grain yield and weed infestation of rice (variety ROK 11) cultivated with Azolla or urea - N in the associated mangrove swamp at Rokupr.

Treatments	Average tillers/ plant	Panicle weight (g)	Spikelet sterility (%)	1000 grain wt. (g)	Mean grain yield (kg/ha)	Dry weed weight (g/m2)
Without N or Azolla	8	1.9	9	22.5	1812	37.4
Urea N - 40 kg per ha	11	2.2	12	25.5	3046	72.4
Azolla monocrop	10	2.3	9	27.4	2983	74.4
Azolla dual crop	10	2.3	8	26.4	3045	5.6
C.V. %	13.1	10.3	24.5	9.1	12.0	65.0
L.S.D. 0.05	1.7	0.3	3.1	3.2	451.7	42.5

Growth of Azolla was less rapid when intercropped with rice than when grown as a monocrop. However, the former practice under dual cropping was beneficial and may be desirable in reducing weed infestation of swamp rice. This is consistent with results obtained in the past and may have considerable implications for reducing labour use in control of weeds in rice.

Complementary use of Azolla and chemical nitrogen: A trial was established in the associated mangrove swamp at Rokupr to evaluate rice response to complementary use of Azolla and chemical sources of nitrogen and to determine the trend in soil fertility under intensive cropping of Azolla.

Grain yield data in the second cropping season of the trial showed an increasing response to nitrogen, irrespective of the method of Azolla cropping (Table 6). Rice grain yield was significantly higher in the Azolla monocrop than yields from other methods of Azolla cropping. Monocropping Azolla, without supplemental nitrogen, was as effective as applying 40-60 kg/ha of urea - N in increasing grain yield. The highest yield was obtained by supplementing the Azolla monocrop with 60 kg N per/ha.

Table 61 Grain yield (kg/ha) of ROK 11 showing response to complementary use of Azolla and mineral nitrogen in the associated mangrove swamp at Rokupr.

Azolla cultivation	Urea - N applied (kg/ha)				
	0	20	40	60	Mean
Without	3008	3797	4319	4413	3884
Monocrop	3982	4695	4772	5522	4743
Intercrop	3447	3548	4577	4556	4094
Mean	3497	4013	4556	4676	

C.V. % = 8.2
L.S.D. 0.05 for comparison between two treatment means = 581.1
L.S.D. 0.05 for comparison between two Azolla cultivation = 394.9
L.S.D. 0.05 for comparison between two nitrogen means = 456.0

Adverse soil amelioration

Residual effect of rice husk application: Rice growth and response to nitrogen is constrained by iron and aluminium in the highly leached soils (Sulfic Tropaquept) on the seasonally inundated, tidal limit of the mangrove swamp catena.

Evaluation of crop performance in the second season after husk application showed that rice grain yield was 0.6 tons/ha higher on the average, with soil amendment (significant at the 5% level) in comparison to the treatment without husk. Rice grain yield response to applied nitrogen continued to be significantly affected by the soil amendment in the second season after application.

Improvement in crop performance with incorporation of rice husk may be attributable to an improvement in the availability and uptake of nutrients particularly nitrogen by the crop.

The high content of Silicon probably accounts for the response of the crop to high levels of nitrogen (120 kg per ha) in the husk treated plots.

Availability and uptake of phosphorus was also expected to improve as a result of decreased P fixation in the soil amended with rice husk.

III PEST MANAGEMENT

Research activities of the season covered studies on population, biology and ecology of the major pests, crop loss assessment on the key and potential pests and the development and testing of alternative pest control packages/monitoring systems for the major pests in the mangrove swamp rice ecology.

Weed Control

Cultural Weed Control Methods

Effect of Variety and crop density on weed growth and rice grain yield: In the trial to test the effectiveness of two rice varieties grown at three densities in checking weed growth and improving grain yield, ROK 5 produced higher grain yield than ROK 10 at all densities tried (16, 25, 33 hills/m2). At 25 hills/m2 (20cm x 20cm) crop densi-ty, grain yield was optimised in both varieties.

Effect of varieties and weeding methods on weed growth and yield of rice: The trial conducted compared five medium duration varieties (135-155 days) under three weeding regimes in the associated mangrove swamp. The weeding regimes did not effectively control weed growth (Table 7). However, in comparison with the unweeded (control) plot, weeding twice produced significantly higher grain yields of rice.

Leaf area index (LAI) ranged from 0.45 in Pankaj to 0.34 in RD 15 indicating differences in canopy cover of the varieties tested. Variety WAR 1 was more competitive against weeds than the other varieties in the trial. Differences in grain yield of the rice varieties presumably reflect inherent differences in the yield attributes of the varieties tested.

Cultural control methods for weeds in rice especially in the associated mangrove swamps are by far the most attractive alternative to herbicides, and are less hazardous to the environment, aquatic and human life.

Table 7: Effect of 5 medium duration varieties and 3 weeding regimes on weed control and grain yield in an associated mangrove swamp.

Varieties	WEEDING REGIMES: No weeding		One handweeding at 21 DAT		Two handweeding at 21 and 30 DAT		Mean	
	Dry weed weight (g/m2)	Grain yield (kg/ha)	Dry weed weight (g/m2)	Grain yield (kg/ha)	Dry weed weight (g/m2)	Grain yield (kg/ha)	Dry weed weight (g/m2)	Grain yield (kg/ha
RD 15	3.7	2882	2.2	2824	1.7	3211	2.5	2972
WAR 1	0.7	3141	1.8	3175	2.3	3416	1.6	3244
ROK 5	2.8	2414	5.9	2595	5.0	3517	4.6	2842
Kau 2039	3.8	2369	6.0	2878	2.1	3271	4.0	2839
Pankaj	4.1	1865	2.8	2627	3.2	3200	3.4	2564

L.S.D. 0.05 for comparison between two treatment means: Weed weight = 3.9NS g/m2
Yield = 775 kg/ha
L.S.D. 0.05 for comparison between two weeding regimes means: Weed weight = 1.8NS g/m2
Yield = 346 kg/ha

C.V. (%) Yield = 16.0; Weed weight = 13.7

NS = Not significant; DAT = Days after transplanting

Effect of seedling establishment methods on weed growth and grain yield of rice: The trial evaluated broadcast of unger-minated and pregerminated seeds; direct seed drilling and trans-planting of 4, 6 and 8 week old seedlings.

The results of this trial showed a similar trend with those of the 1985 season. There were no significant differences among treatments for weed count and dry weed weight. The rice grain yields of transplanted 4, 6 and 8 week old seedlings were 1799, 2361 and 2066 kg/ha respectively as compared to the yield of 1565 kg/ha for ungerminated seed broadcast, 1532 kg/ha for pregerminated seed broadcast and 1620 kg/ha for direct drill seeded rice.

Direct seeding in the associated mangrove swamp cuts down on expensive labour needed for transplanting. The results further show that there is no need to transplant seedling older than 4 weeks in the associated mangrove swamps where the crop is not prone to crab or fish damage.

Effect of cultivation and weeding methods on weed control and grain yield of rice: Past field surveys of weeds have established that weed flora in the associated mangrove swamp was similar in Sierra Leone and Guinea. Therefore, an evaluation of cultivation and weeding method on rice yield was undertaken this season in the Coyah region of Guinea. Handweeding treatments produced higher yields than the no weeding control (Table 8). The mechanical cultivation treatments produced higher yields of rice than manual cultivation treatments under all weeding methods. Yield increases were 15, 10, and 17 percent respectively.

The results of Guinea confirmed the findings in Sierra Leone that mechanical cultivation is superior to manual cultivation in suppressing weed growth and increasing rice grain yields in the associated mangrove swamps.

Chemical weed control

Promising herbicides: The herbicides Tamariz, Arozin D and Basagran PL2, were tested along with Stam F34T, the local standard herbicide. The highest grain yield of 3454 kg/ha was obtained with Tamariz applied at the rate of 10 l/ha 10 days after transplanting (DAT). PL2 applied at the rate of 6 l/ha 10DAT gave grain yield of 3321 kg/ha. With an additional handweeding grain yield increased.

Disease control

Studies were carried out on the incidence of rice nematode diseases in the mangrove swamp rice ecology and rice yellow mottle virus (RYMV). An integrated control package for rice brown spot disease was formulated and tested for the first time.

Rice nematode diseases: The 'white tip' nematode caused by Aphelenchoides besseyi has been previously reported occurring in mangrove swamp rice fields in some parts of Sierra Leone, in the Gambia, Guinea and Guinea Bissau. A trial was

carried out to verify and assess the incidence of these rice pathogens in mangrove swamps at Rokupr and to facilitate the development of an appropriate control strategy. Twelve recommended and promising mangrove swamp rice varieties were tested and results obtained from CIP confirmed that only the 'white tip' nematode, A. besseyi infected the samples.

The number of nematodes from 100 grain samples ranged from 0 on Gantang to 45 on ROK 5 in seed samples obtained from an associated mangrove swamp rice at Rokupr; a range of 22 on ROK 8 to 152 on ROK 5 was obtained in samples from a tidal mangrove swamp at the same site. On the average, nematode infestation was 2.5 times higher on the tidal mangrove swamps than in associated swamps. Symptoms of presumptive 'ufra' were observed on six varieties, namely Rohyb 15-WAR-3-3-B-2 (WAR 1), ROK 5, ROK 7, ROK 8, ROK 9, and SR 26. The symptoms were invariably expressed as partial exsertion of affected panicles or complete failure of panicle to emerge with resultant rotting within the leaf sheath. Sheath rot symptoms probably caused by Sarocladium oryzae were also often observed on affected plants.

Rice yellow mottle virus disease (RYMV): This is a potential disease problem of lowland rice. Most of the recommended and promising mangrove swamp rice varieties in Sierra Leone have been found to be susceptible. Investigations continued this season to observe the behaviour of 22 resistant and/or tolerant rice accessions artificially inoculated with RYMV under increasing levels of nitrogen.

Nitrogen application did not affect the severity of virus on upland rice varieties tested. At levels above 40 kg N/ha, the virus produced severe mottling in the mangrove swamp varieties tested except WAR 36-40-4-2, WAR 39-50-2-3 which produced severe mottling at 60 kg N/ha. Some traditional varieties produced mild mottling even at 80 kg N/ha level, such as Angkata, Kpenyei (Red) 191. All the upland varieties tested produced mild mottling at 0 - 80 kg N/ha levels.

Table 8: Effect of cultivation and weeding methods on weed control and rice grain yield of Rohyb 6 in an associated mangrove swamp in Coyah, Guinea

Cultivation Method	No weeding		One handweeding at 21 DAT		Two handweeding at 21 DAT AND 31 DAT		Mean	
	Weed count/m2	Yield (kg/ha)	Weed count/m2	Yield (kg/ha)	Weed count/m2	Yield (kg/ha)	Weed count/m2	Yield (kg/ha)
Manual with traditional hoe	47	5025	41	5500	28	5925	39	5483
Mechanical with power tiller	37	5800	23	6023	25	6900	28	6242
Mean	42	5413	32	5763	27	6413		

L.S.D. 0.05 for comparison of two treatment means: Weed count = 11/m2; Yield = 1051 kg/ha

L.S.D. 0.05 for comparison of two weeding methods means: Weed count = 8/m2; Yield = 744 kg/ha

L.S.D. 0.05 for comparison of cultivation methods means: Weed count = 6/m2; Yield = 607 kg/ha

C.V. (%) weed count = 21.3; Yield = 1.9

DAT = Days after transplanting

Integrated Control

Rice brown spot disease (*Helminthosporium oryzae*) caused by *Cochliobolus miyabeanus* is a key disease in mangrove swamp rice ecology. Significant losses in grain yield due to the pathogen have also been recorded on transplanted rice in Sierra Leone and Guinea. Two treatments, namely, (a) early transplanting in July, and (b) early transplanting in July followed by fungicide application at the flowering/milk stage of rice growth. Designated integrated control packages were compared, using the fungicide, Benlate (Benomyl) and Kocide 101 applied as a mixture at 1.0 kg a.i/ha.

The integrated control package yielded 3614 kg/ha of rice compared to 3233 kg/ha in the treatment without fungicide application. Brown spot severity in the integrated control package plots was 4.8 percent leaf area damaged on the average

compared to 5.2 percent in the plots with no fungicide treatment. Incidence of other diseases and insect pests was negligible at this site. The integrated control package increased grain yield by 11.8 percent indicating the superiority of integrated control in this trial.

Insect and Crab Control — Mangrove

Stem borer attack in the upland rice nursery: In a preliminary survey of established upland rice nurseries around Rokupr it was observed that crop infestation by Maliarpha in the 60 day-old nursery was higher than infestation in the 42 day-old nursery. No Maliarpha larvae were found in rice seedlings sampled from 30 day-old nurseries. Sesamia sp. and Diopsis sp. also attacked the rice crop as early as the nursery stage. When confirmed, these findings would facilitate the determination of an appropriate timing of control measures.

Rice crop infestation by Maliarpha: Previous studies have shown M. separatella moths to occur throughout the year in a bimodal distribution with a low peak in May and a high peak in November. Intensive field studies undertaken this season have indicated that oviposition extended up to the heading stage of the rice crop. Highest number of Maliarpha egg batches were collected at late booting to heading stages of the rice crop (17-18 weeks after transplanting). At the tillering stage, the eggs were concealed in a foliar envelope on the central leaf. At booting to heading stages, the eggs were found on the open leaf with no folial envelope. No eggs were found on the rice crop during milk to mature stage (Figure 3). Generally, the lower internodes were preferred for feeding by developing larvae.

Figure 3. Maliarpha separatella egg oviposition in the crop.

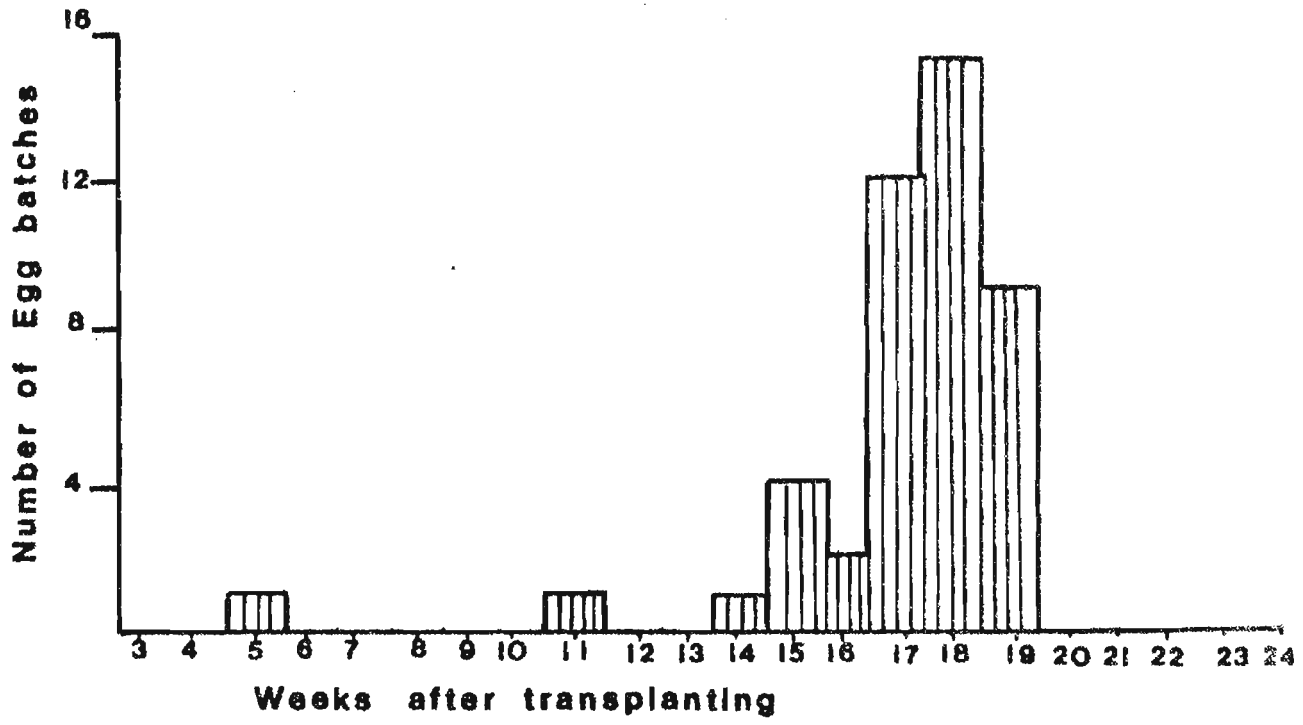


Fig. 3 Maliarpha separatella egg oviposition in the rice crop

The number of parasitoids emerging from field collected larvae reared in the laboratory and from field observations indicated that larval parasitism was highest between 10 and 18 weeks after transplanting. This period coincided with peak Maliarpha oviposition in the field, a coincidence which may enhance

effective parasitism of subsequent emerging M. separatella larvae. Up to 30 percent parasitism was recorded in the field. Phanerotoma major Brues. was the most prevalent parasitoid followed by Venturia crassicaput (Morley).

Synthesis and field testing of Maliarpha sex pheromone: Synthesis and field testing of the female sex pheromone of M. separatella continued. The pheromone has been found to contain three closely related alcohols.

Two of the alcohol components (II OH and III OH) were found to be essential for attractancy. The third alcohol component (I OH) has not been found to be effective in the attraction of male moths in the ratios tested. The optimum ratio for the binary mixture was found to be approximately 10:1 II OH to III OH (Table 9).

Table 9: Comparison of four pheromone binary mixtures of II OH and III OH in attracting male Maliarpha moths

Pheromone binary mixture			
I OH	II OH	III OH	Mean Moth catch
0	97.5	2.5	7.75ab
0	95.0	5.0	10.75a
0	90.0	10.0	10.50a
0	80.0	20.0	5.25 b

Means followed by the same letter in the column are not significantly different at DMRT .05

All lures tested appeared to decrease in attractancy over the first week of exposure in the field, possibly due to the effect of release rate from the rubber septa.

Monitoring of Maliarpha by pheromone: The ratio of 3:6:1 blends of I, II, and III alcohol components of M. separatella sex pheromone identified last year was used this season to monitor M. separatella population fluctuations around Rokupr for the first time. Moth catches made by the pheromone traps compared favorably with those caught by light traps installed around Rokupr (Table 10).

Table 10: Comparison of male Maliarpha separatella moth catches by pheromone and light traps installed in rice fields around Rokupr (August - December, 1986).

Period	Total Maliarpha moth catches/trap		
	kerosene light	Electricity powered	Synthetic pheromone 1/
19/8/86 - 1/9/86	8	8	8
2/9/86 - 15/9/86	15	8	2
16/9/86 - 29/9/86	10	1	4
30/9/86 - 13/10/86	29	16	11
14/10/86 - 27/10/86	-	21	10
28/10/86 - 10/11/86	14	14	12
11/11/86 - 24/11/86	-	89	17
25/11/86 - 8/12/86	-	-	17
9/12/86 - 22/12/86	1	-	8

- = Indicates no data obtained during the period
1/ = Total of 5 traps at one site

Crop loss assessment

Six improved rice varieties were assessed from grain yield losses attributable to insect pests at Rokupr Station under four levels of management. Generally, grain yield loss in the fertilized crop was lower than in the unfertilized crop except for ROK 5 and WAR 1. As much as 19.3 percent yield loss was observed for ROK 10 under unfertilized conditions, a level which could be alarming considering the farmers' present weak technology.

WAR 1, Rohyb 4-WAR-1-3-B-2, and Rok 5 (147-155 days) were less tolerant to stem borer attack than Rohyb 6-WAR-6-2-B-2, Kuatik Kundur and ROK 10 that were of longer duration (165-190 days). Insecticidal protection of the crop in the field alone using carbofuran increased grain yield nearly as well as applying 40kg N/ha. When the crop was protected in the field and at the same time fertilized, grain yield was increased by about 40 percent. This establishes a basis for considering the inclusion of an insect pest protection measure alongside a fertilization package developed for the farmer.

Integrated pest Management

Field trials in the past had identified agronomic practices and other forms of control measures which tended to minimize pest damage to the rice crop. An integrated pest management (IPM) package for the control of crabs formulated out of these findings at Rokupr was tried for the first time this season.

Preliminary results indicated that the IPM package (vigorous seedlings - fertilized in the nursery, close transplanting - 32 hills/m^2, six seedlings/hill) was significantly better than the farmers' standard practice (weak seedlings-no nursery fertiliza-tion, wide spacing-16 hills/m^2, 16 seedlings/hill) in minimizing crab damage under both fertilized and unfertilized field situations (Table 11). The IPM package increased grain yield in the improved variety ROK 10 by 272 and 205 percent under fertilized and unfertilized field situations respectively at Kagbanha, a site prone to severe crab infestation on the Scarcies estuary.

Table 11: Comparison of a prototype IPM strategy with farmers' standard practice for control of crabs under two levels of management at two locations along the Great Scarcies tidal swamps in northwest Sierra Leone.

Control package	Percent Crab Damage				Grain Yield (kg/ha)			
	Kassirie fertilizer		Kagbanha fertilizer		Kassirie fertilizer		Kagbanha fertilizer	
	With	Without	With	Without	With	Without	With	Without
IPM	36.0	43.0	47.9	52.0	2940	2256	1168	991
Farmers' Practice	57.2	63.3	66.2	72.0	2133	1544	314	325

LSD .05

	Percent crab damage	Grain Yield (kg/ha)
Kassirie	8.2	310
Kagbanha	5.4	480

IV. TECHNOLOGY ASSESSMENT AND TRANSFER PROGRAM

The objective of the Technology Assessment and Transfer (TAT) program is to identify constraints that limit rice production in the mangrove swamps and develop technologies to solve those constraints. In 1986, constraint identification studies, on farm verification (researcher - managed), adaptive (farmer-managed) trials and on-farm demonstrations were conducted. Some seed exchange program activities were also carried out.

A. CONSTRAINTS IDENTIFICATION

Socio-economic baseline studies: The major socio-economic factors determined were labour distribution, income and farm prices for two representative villages, Kibola and Kalexe in the Boke and Boffa districts of Guinea.

Labour distribution: Two labour peaks in the Kibola area were identified (Figure 4). The first peak in March coincided with the period of harvesting and threshing. The second peak in September coincided with ridge construction/ploughing, nursery practices and transplanting on the main rice fields.

At Kalexe, labour utilization reached its peak in September (122 man days/month) when ridge construction and transplanting were most intensive.

Figure 4. Average labour Distribution on Farm Activities in Kibola (Boke district) and Kalexe (Boffa district), Guinea.

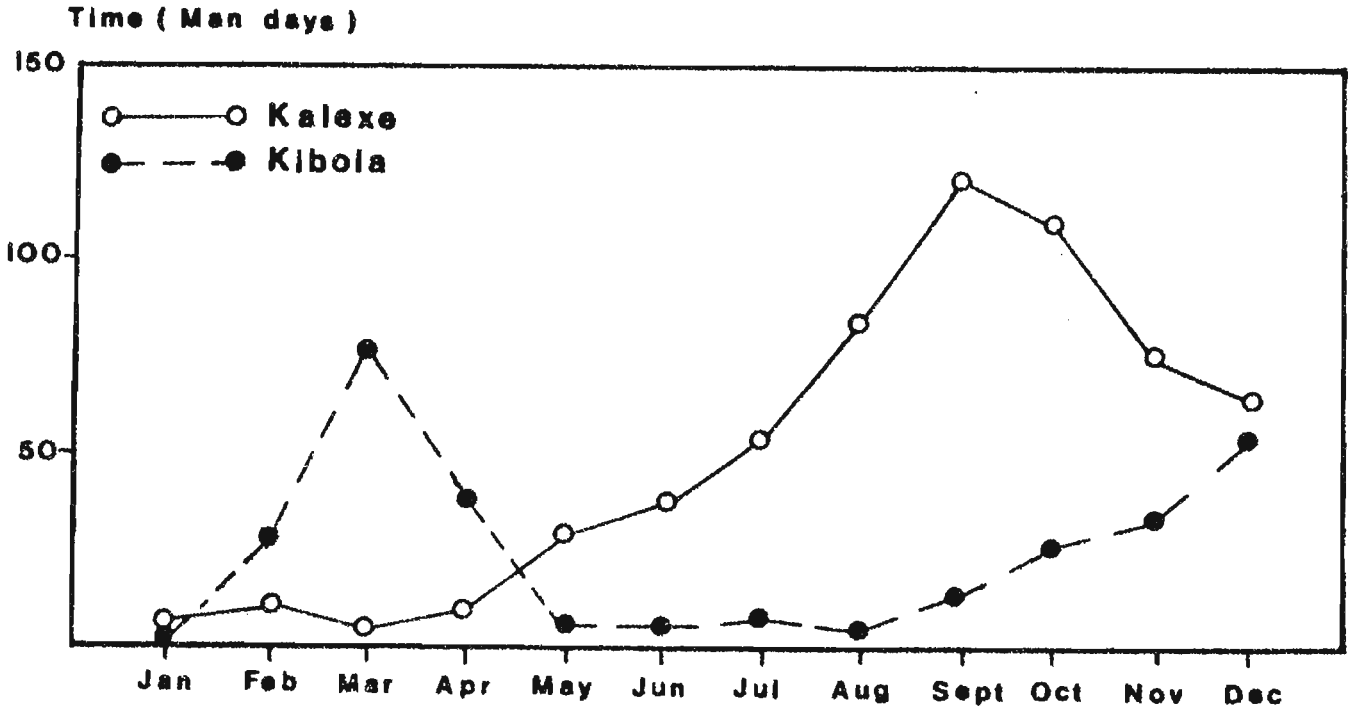


Fig.4 Average Labour distribution on farm activities in Kibola(Boke district) and Kalexe(Boffa district) Guinea

Given the low adult membership of households in the two areas (four on the average) the high labour demand at the peak of farming operations suggests that farm expansion would be difficult. New technology should therefore focus on increase of

paddy per unit area of land. This could be achieved by the use of improved varieties, fertilizer applications and appropriate crop protection measures as has already been shown in the component research. Possibility of mechanization in threshing and winnowing could be considered to reduce demand on labour during peak periods. However, mechanical ploughing may be difficult to implement because of the ridge system of cultivation.

Gross income: Farmers in Kibola received their highest income (GF13,194 - 15,595) in April-June from the sale of rice grown on the main fields and from oranges. Sale of rice from the periphery of the main fields in December boosted income slightly. Income tended to be very low (GF 869-2,797) in the periods January-February and September -October, preceding rice harvest. The expenditure level at Kibola was also highest in April, the peak income period, when higher sales of farm produce tended to influence higher spending, including debt payments.

Farmers in Kalexe received their highest income (GF 10,090 - 14,952) in January-February from the sale of rice. The sale of other agricultural produce boosted income slightly (GF 7,807) in October. The highest expenditure for Kalexe occurred in September when labour use in rice farming was most intensive. Despite a generally higher income of farmers at Kalexe compared with Kibola, the net income flow at Kalexe was consistently lower because of higher expenditures.

The low level of income at Kibola and Kalexe necessitates the use of low input technologies for increasing rice production.

Rice price in the Boke/Boffa Districts of Guinea: The price of milled rice at Kalexe was at its lowest, GF 2,120 per "estagon" (12 kg), during the harvest period in November-December. The price of rice per estagon rose to GF 2,400 in January-March and further up to GF 3,600 in April-July when rice was very scarce. The price was depressed to GF 2,360 per estagon during August-October when other agricultural crops, e.g. sweet potatoes, millet, yams and cocoyams were harvested.

In kibola, milled rice price was at its minimum (GF 2,200-2,600 per estagon) in March-April and October-November when harvesting and threshing operations had started. The price of rice tended to be high (GF 3,600) in August, when produce was mostly in the hands of traders.

It was observed that most farmers tend to sell their rice at periods of low prices. This may be due partly to lack of adequate storage facilities and/or low levels of income, compelling farmers to place their crop in the market immediately

after harvesting. Government intervention may be needed to assist the farmers. This could include the following: (a) formation of cooperative marketing societies to share the use of modern storage facilities (b) price guarantees; and (c) cash credit.

B VERIFICATION TRIALS

Variety Trials: Eighteen promising varieties/advanced lines were tested in three sets of medium and long duration farmers' field trials (FFTs). The trials were conducted at 35 locations in Sierra Leone (13), The Gambia (6) and Guinea (6).

Medium duration (120-155 days): Average grain yield per location varied from 2622 kg/ha at Samu, a salt affected site in Southern Sierra Leone, to 3127 kg/ha at Sonfonia in Guinea. A new advanced line, WAR 52-384-3-2, gave an average grain yield of 3450 kg/ha outyielding both WAR 1 and ROK 5 under saline and non-saline conditions. WAR 1 gave an average grain yield of 3050 kg/ha.

Long-duration (155-180 days): In Sierra Leone, Guinea and the Gambia, the three best varieties were WAR 44-50-4-1, WAR 44-5-5-2 and WAR 44-5-1-3 with an average grain yield of 2699, 2716, and 2658 kg/ha, respectively. WAR 44-5-5-2 and WAR 44-50-4-1 were the top varieties in The Gambia and in Sierra Leone/Guinea, respectively.

In the second category of long duration (180-200 days) trials tested in Sierra Leone, Guinea and The Gambia, only Maung Nyo B24-92 outyielded CP 4 (check variety) with an average grain yield of 3418 kg/ha, while farmers' varieties yielded 2109, 2661 and 2825 kg/h, respectively in the same countries.

Region wide Advanced Variety Trials (AVTs): Two sets of AVTs were conducted in Sierra Leone, Guinea and Guinea Bissau.

Medium duration: In Sierra Leone and Guinea-Bissau, average grain yield of 1309 kg/ha was obtained for Samu, in Southern Sierra Leone and 3646 kg/ha for Caboxanque in Southern Guinea-Bissau. On the average, Rohyb 4-WAR-1-3-B-2 and WAR 1 were the two top varieties with grain yield of 3084 and 3017 kg/ha respectively. Days to maturity of the twat entries over different locations ranged from 128 days for IR 11248-B-2-2-2 at Caboxanque (Guinea-Bissau) to 150 days for Rohyb 1-1 at the Rice Research Station in Rokupr, Sierra Leone.

Long duration: Average grain yield was 2816 kg/ha at Saiama (Southern Sierra Leone) and 4681 kg/ha Maneah (Guinea). The other location at Rokupr Rice Research Station gave an average grain yield of 2824 kg/ha. A new advanced line, WAR 39-17-2-2, had the highest average yield across the four locations, while Neang chock and WAR 24-21-3-2 which ranked first and second in 1985, were sixth and second, respectively this season. Moyamban 1 which had ranked first for two consecutive seasons at Maneah (Guinea) did not perform as well in other locations. It is not as widely adapted as WAR 39-17-2-2, WAR 44-21-3-2 and Rohyb 6-2-8-2 which had ranked among the top five varieties for three consecutive seasons. The average number of days to maturity varied from 172 days at Maneah (Guinea) to 190 days at Rokupr, Sierra Leone.

Soil and Crop Management trials

Nitrogen and phosphorus responsive trials: Extensive testing of rice response to nitrogen and phosphorus fertilizers was undertaken on farmers' fields in The Gambia and Guinea to evaluate rice response to the combined application of the nutrients and to determine optimum levels of fertilizer requirement.

Figure 5. Rice response to phosphorus with and without nitrogen on farmers' fields in The Gambia and Guinea.

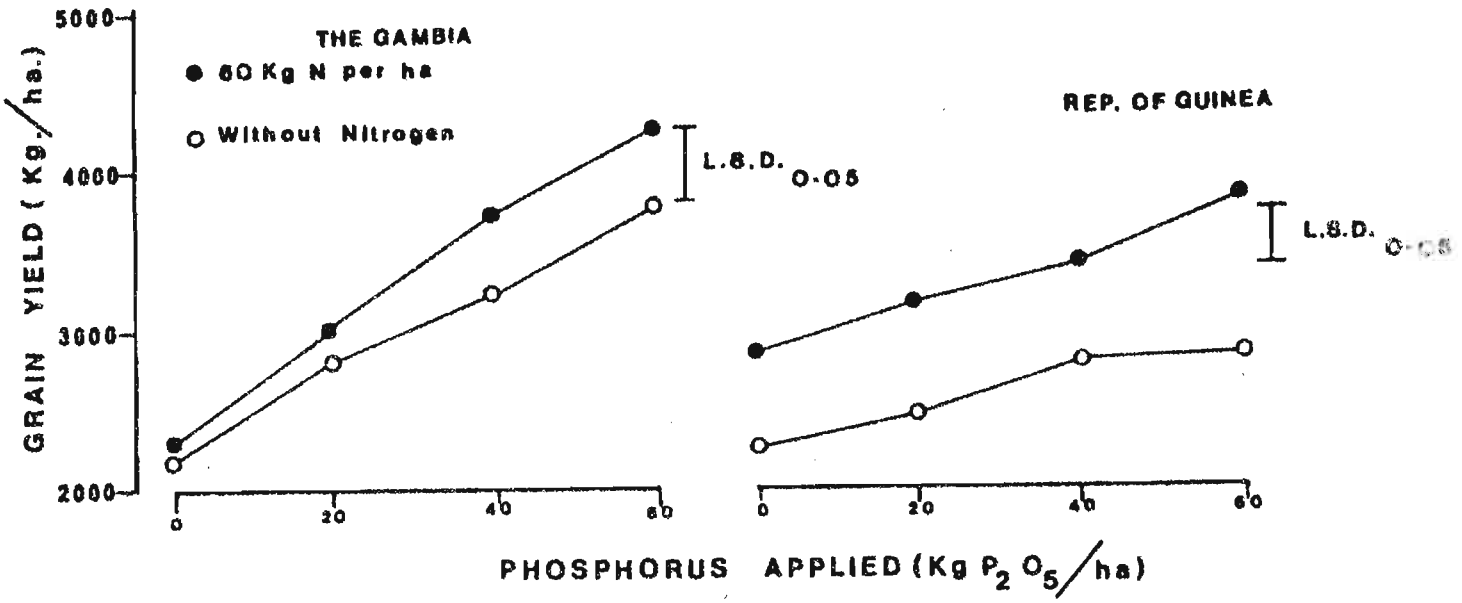


Fig.5 Rice response to Phosphorus with and without Nitrogen on farmers' fields in The Gambia and Guinea.

Application of both nutrients to rice improved grain yield significantly but the level of response to individual nutrients differed markedly in the two countries (Figure 5). In The Gambia, rice grain yield response to phosphorus was linear. Successive intervals of phosphorus produced significant increases in rice grain yield. The addition of nitrogen was not effective in improving grain yield at levels of phosphorus below 40kg P_2O_5 /ha. This is presumably a consequence of the prevailing acid sulphate conditions in the mangrove swamps of The Gambia under limited rainfall and short periods of flooding. Thus, the observed response to nitrogen was probably conditioned by the level of phosphorus in the soil.

In Guinea, rice grain yield response to phosphorus at 40 kg P_2O_5 /ha . was significant but application of additional nitrogen was more effective in increasing the grain yield of rice. The high precipitation (2500-3000 mm) in Guinea and prolonged soil submergence could also account for the increase in yield. Relative to the farmers' practice, increases in rice production of 38-92% and 42-68% were obtained with application of the two nutrients in The Gambia and Guinea respectively. Phosphorus was more important for mangrove swamp rice production in the Gambia than in Guinea.

Azolla trials: The use of composted farm debris as an alternative to phosphorus for improving Azolla growth and the performance of rice cultivation with Azolla were assessed on farmers' fields in Sierra Leone and Guinea.

The Azolla pinnata Strain ADUL 138 showed adaptability to wide-ranging swamp conditions in Sierra Leone and Guinea. An inoculum of 400g/m^2 of ADUL 138 yielded 1.712 kg/m^2 on average in 21 days. The farm compost (2kg/m^2) provided a useful medium for Azolla growth. Biomass production of Azolla was higher and less variable under compost (1802g/m^2) than with the application of phosphorus (1678g/m).

Rice cultivated with Azolla on farmers' fields produced similar grain yields of rice as the application of 40 kg/ha of urea-N. This exceeded yields of the control plots (40 kg P205/ha; without N or Azolla - 2089 kg/ha in Guinea and 977 kg/ha in Sierra Leone) by a margin of 44 percent and 68 percent in Guinea nd Sierra Leone respectively. Supplementing Azolla with 20 kg/ha of urea-N and combination of Azolla with compost increased grain yield of rice by 424 kg and 329 kg/ha, respectively over cultivation of Azolla in the Sierra Leone swamps. In Guinea these treatments did not effect any increase in the grain yield of rice. Azolla suppressed weed growth.

The results indicate that cultivation of Azolla is feasible and can be immensely beneficial for rice production in inland swamps. The difficulties encountered with water control on farmers' fields suggest that the Azolla technology may be more appropriate for swamps with effective water control systems. Therefore, characterization of swamps with potential for Azolla utilisation in rice cultivation should be an essential pre-requisite for implementation of Azolla technology. Criteria for assessment of swamps for Azolla utilization must include the period of availability and level of water flow; availability of nutrients, particularly of phosphorus, and the adaptability of Azolla species/strains.

Pest Management trials

Disease surveillance and monitoring: In 1986, the most prevalent diseases recorded on mangrove swamp rice in Sierra Leone, Guinea, The Gambia were brown spot (Cochliobolus miyabeanus), leaf and neck blast (Pyricularia oryzae), leaf scald (Rhynchosporium oryzae), narrow brown leaf spot (Cercosporaoryzae), and 'dirty panicle' (discolored grains). Brown leaf spot and grain discoloration syndrome were particularly severe at all sites; high levels of folial infection of brown spot were noted at Moribaia and Kibanka in the short season zone of the Scarcies estuary. 'Dirty panicle' incidence was also high at Moribaia, an area prone to salinity. Disease pressure was low in Guinea and The Gambia. However, in an associated swamp at Koba (Guinea), symptoms presumably of rice Bakanae disease (GobberellaFujikuroi) were observed on direct seeded rice. The affected rice plants, showing excessive elongation of internodes, were randomly dispersed in the field. Symptoms presumably of 'white tip' nematode (Aphelenchoides besseyi) disease were also found on farmers' fields in The Gambia.

Crop Loss assessment

Grain Yield losses on Farmers' Fields: An assessment of grain yield loss due to diseases on farmers' fields was undertaken in Sierra Leone and Guinea in the last cropping season.

Results obtained showed 9.1 and 18.6 percent losses in grain yield due to prevalent rice diseases at Rotifunk in Sierra Leoneand Donia in the Coyah region of Guinea respectively. These levels of grain yield losses were comparable to those recorded in

previous seasons in both verification and adaptive farmer-field trials. Brown spot, leaf blast and leaf smut were the prevalent foliar rice diseases at both sites. The result supports the contention that considerable yield losses can be incurred as a result of the prevalence of pathogens in mangrove swamp cultivated rice.

C. ADAPTIVE TRIALS

Balansera, short season and Kychom, medium season zones, were selected along the Great Scarcies River for testing of the following technological packages:

Improved varieties WAR 1 (145 days), Rohyb 6-WAR-6-2-B-2 (165 days) and traditional variety without fertilizer; Improved and traditional varieties plus 40 kg N/ha of rice by injection method.

In the Balansera zone, WAR 1 plus urea outyielded the traditional variety by approximately 1.5 tons per hectare, an increase of 113 percent.

The new package increased net income over the traditional practice by Le5,058, equivalent to approximately 1.4 tons of paddy. WAR 1 alone outyielded the traditional variety by 21 and 41 percent in 1985 and 1986 seasons respectively. The response of the traditional varieties to urea injection resulted in a yield increase of 44 percent.

In the Kychom zone, the package of Rohyb 6 plus urea-N outyielded the traditional practice by approximately 2 tons/ha, equivalent to an increase of 108 percent. The attributable net benefit was approximately Le2,000/ha, equivalent to 1.9 tons/ha. of rice. The package of Rohyb 6 alone increased rice production by a margin of 1 ton/ha, equivalent to Le3,741. The application of urea-N to traditional varieties created an additional net income of Le2,079.

The results of the 1986 trials in Kychom and Balansera indicated that WAR 1 could be more suited to the Balansera area than Kychom.

Guinea: A package of WAR 1 plus urea (40 kg N/ha) by injection method was tested in the Kobaya and Yattaya/Sonfonia zones of Conakry region. This package outyielded the traditional practice by 743 kg/ha (52%) and 493 kg/ha (29%) respectively.

The corresponding additional net revenues were GF 29,760 and GF 14,700. Despite the generally low yields of rice in the Kabaya area this year, the performance of the new package was an improvement on the traditional practice.

The package of Rohyb 6 plus urea by injection method tested at Yattaya/Sonfonia in the Conakry region gave yield increase of 954 kg/ha (43%), with an additional net benefit of GF 44,820; and 902 kg/ha (51%) with increased net benefit of GF 41,700 in the Kobaya zone. In the Coyah area, the same package outyielded the traditional practice by 937 kg/ha (48%), giving an added net revenue of GF 43,800. It is noteworthy that yield gaps between the package of Rohyb 6 plus urea and the traditional practice were similar in all the areas where the package was tested.

In the treatments where no N was applied WAR 1 outyielded the traditional varieties by a margin of 17-27 percent, averaging 300-384 kg/ha. The Rohyb 6 package outyielded the traditional varieties in the range of 16-34 percent or 309-621 kg/ha. Urea alone gave increases between 295 kg/ha and 1024 kg/ha, i.e 17-59 percent.

WAR 1 has shown considerable promise in improving rice production in the adaptive trials in Guinea over the last two seasons.

The Gambia: The adaptive trials were carried out at Kaur, N'jain Sanjal, Sarakunda, Jareng, Pakaliba and Bureng zones.

The package WAR 1 plus urea yielded 14 percent or 324 kg/ha above the traditional practice. This gave an additional net profit of D.115. The package of Rohyb 6 plus urea outyielded the traditional practice by a margin of 800 kg/ha (29%), producing an additional net benefit of D.697.

D. DEMONSTRATIONS

In Sierra Leone 397 farmers participated in field days organized by the North Western Integrated Agricultural Development Project (NWIADP), Adaptive Crop Research and Extension (ACRE), and the Moyamba Integrated Rural Development Project (MIRDP) in 25 farm demonstrations using WARDA's recommended paractices.

The combined effect of nitrogen and phosphorus, especially, showed a marked yield gap (143%) over the traditional practice in iron toxic areas in the associated swamps. The package of improved variety (ROK 10 or Kuatik Kundur), nitrogen (N40) and mechanical ploughing (MP) yielded an average of 50 percent higher than the traditional practice on 22 farms in the Great Scarcies and Bumpeh areas of Sierra Leone.

Another set of demonstration was established in 5 nurseries in the Great Scarcies area using 15:15:15 in the nurseries. It was observed that the fertilized plots (10m2) produced more vigorous seedlings weighing 15 kg on average while the farmers' non-fertilized plots weighed 13 kg per plot. Morevover, the vigorous seedlings from the fertilized plots planted an average of 131 m2 as against 108m2. The impressive seedling economy and vigour resulting from the application of fertilizer in the nursery were noted by farmer participants.

In the Conakry and Coyah region of Guinea the demonstrations of WARDA's package by the Ministry of Agriculture was also successful. The package of Kuatik Kundur plus urea (40 kg N/ha) plus mechanical ploughing also outyielded the traditional practice by an average of 50 percent. A total of 117 farmers witnessed the results during the field days.

E. SEED EXCHANGE

Seeds in one kilogram packets of improved variety WAR 1 were exchanged with an equal quantity of their local rice with 40 farmers in Sierra Leone, 25 farmers in Guinea and 5 farmers in The Gambia, through the national extension agencies. The objective was to monitor yield performance of the improved variety and the manner in which they utilized the produce i.e. for consumption, trade or seed for the next crop. In Sierra Leone, the yield obtained with WAR 1 in the short season areas was about 81 percent higher than that of traditional varieties. Similarly, the yield of Rohyb 6 variety which was exchanged with 20 farmers in Sierra Leone was double that of farmers' varieties.

V. COLLABORATION WITH NATIONAL AND INTERNATIONAL PROGRAMS

A. NATIONAL PROGRAMS

Sierra Leone: With the FAO Inland Swamp Development Project operating in Southern Sierra Leone, the Bayende Small Farmers Development Project at Bayende in Northwest Sierra Leone and the Seed Multiplication Seed Centres at Makeni and Kenema in Northern and Eastern Sierra Leone, WARDA intensified its effort in the identification, selection and testing of suitable low cost technology of Azolla. Azolla strains supplied by WARDA are being used in the improvement of soil fertility and sustenance of crop production in the inland valley swamps of these areas.

WARDA also cooperates with the National Rice Research Station (RRS) at Rokupr in exchanging and testing promising materials and conducting occasional joint seminars. WARDA and RRS jointly initiated a breeding program for developing improved varieties with resistance to RYMV this season.

Assistance to the Seed Multiplication Project (SMP) was in the provision of breeder and foundation seeds for multiplication and distribution to farmers. The SMP received 30 kg each of three varieties, WAR 1, Rohyb 6-WAR-6-2-B-2 and Kuatik Kundur which are being considered for release in Sierra Leone. The Station also assisted the Ministry of Agriculture, Natural Resources and Forestry in the distribution of improved seeds in exchange with farmers' traditional varieties.

Guinea: WARDA's collaboration with the National Institutions, during 1986 involved 30 trials of promising varieties (WAR 1, Rohyb 6-WAR-6-2-B-2, Kuatik Kundur, Raden Mas, Kuda Hirang, etc.), use of fertilizer, and adaptive trials conducted at over 12 locations by personnel of the Ministry of Agriculture. Fifty-five kilograms each of Rohyb 6-WAR-2-B-2 and Kuatik Kundur seeds were given to the Ministry for further multiplication and distribution to farmers.

The performance of WARDA's technology on farmers' fields and its impact on the farmers in Guinea were evaluated jointly by the Director General of Agronomic Research, national research extension personnel and WARDA.

The Gambia: In collaboration with the Freedom From Hunger Campaign (FFHC) Project and the Ministry of Agriculture, over 40 trials of promising technological packages (varieties and fertilizers) were conducted at over 15 locations. WARDA also

collaborated with the Crop Protection Services (CPS) unit of the Ministry of Agriculture in the monitoring of insect pest occurrence and population dynamics to establish baseline information on the major insect pests.

Guinea-Bissau: Five WARDA trials were conducted at the Caboxanque Research Station to test varieties for early maturing and tolerance to salinity.

Guidelines were provided for multiplication and production of good quality seeds at Caboxanque. Assistance was given to the Crop Protection Service (CPS) unit by providing a light trap and synthetic female sex pheromone of Maliarpha for monitoring M. separatella populations in rice fields around Bissau.

Nigeria: The National Cereals Research Institute (NCRI)collaborated with WARDA in testing and evaluating promising varieties/advanced lines developed by WARDA.

Senegal: Trials were carried out with the scientific team at Djibelor Station in Southern Senegal.

B. INTERNATIONAL PROGRAMS

Current activities: During 1986, the Station collaborated with the International Rice Research Institute (IRRI) in the Philippines by testing 1191 lines from various IRRI-IRTP nurseries as follows: IRON (366), ITPRON (63), IRRSWON (203), IRSATON (90), IRBN (386) and Acid lowland screening set (90). The Tropical Development and Research Institute (TDRI) in the UK collaborated with WARDA in the identification, synthesis and field testing of female M. separatella sex pheromone.

VI TRAINING

An intensive in-country training course was organized for one week in The Gambia, in which 26 field technicians representing all agricultural institutions in the country participated. The course covered all aspects of mangrove swamp rice production. The manual "A guide to better mangrove swamp rice cultivation in the WARDA region" produced by the Station was distributed to participants.

Facilities and supervisory support are also provided for 1 B.Sc and 2 M.Sc students from Njala University College in thesis research components of their university degree work. Three Station scientists and a staff of the national Rice Research Station registered with the University of Sierra Leone are being supported by WARDA for Ph.D research programs. The Station Pathologist is a part-time lecturer in plant pathology at Njala University since the 1985 academic year.

Scientists from the WARDA Station participated as resource persons in several training programs organized by N'jala University College, IITA, Ministry of Agriculture, Natural resources and Forestry, and in-service training organized for technicians and instructors of the Crop Protection Services staff of the Ministry of Agriculture of Sierra Leone. The Scientists also participated in the WARDA Regional Training Programs at Fendall, Liberia.

IRRIGATED RICE REBEARCH STATION
BAINT LOUIS, BENEGAL

Introduction

The Irrigated Rice Research Station is based at St. Louis, Senegal, and has four major components, namely (i) varietal improvement, (ii) plant, soil and water management, (iii) insect and disease control and (iv) socio-economic impact. In 1986, activities were conducted in all the major program areas.

Varietal Improvement

The objective of the varietal improvement program is to develop or adapt varieties which can perform better than traditional varieties given the environmental, physical and socio-economic circumstances of West African rice farmers. The varietal improvement program covers (i) collection and utilization of plant genetic resources, (ii) selection of high-yielding varieties through extensive trials and (iii) hybridization.

Evaluation of New Materials

In 1986, a total of 698 new varieties/lines were evaluated on the basis of seedling vigour, tillering ability, plant height, insects and disease resistance, salt tolerance and yield. The trials were conducted at Fanaye during the wet, (humid), hot dry and cold dry seasons. In all the trials, 21-day old seedlings were transplanted in 2 to 3 rows of 5 metres long, 20 x 20 cm spacing with one seedling per hole without replication. In the wet season, 380 varieties were tested and 28 short duration and 24 medium duration varieties were selected for favourable characteristics. In the cold dry season, 53 varieties/lines were selected for vigour and phenotype. In the hot dry season, 14 varieties were selected out of 155 tested for favourable agronomic characters. For tolerance to salinity, 110 lines/varieties were tested and 21 were selected.

Observational, International Yield Nursery, Yield and Coordinated Variety Trials

All these trials were conducted in 1986, transplanting 21-day old seedlings in rows of 20 x 20 cm. NPK was applied at the rate of 120-60-60 kg/ha of NP_2O_5 respectively. Randomized complete block (RCB) design with three replications were used for the observation, international yield nursery and yield trials, while the coordinated variety trials had four replications. In all the trials, data were collected on plant height, duration, yield, number of tillers per m2 and sterility rate.

In the only one observational trial conducted, 10 varieties were selected on the basis of yield, plant height and duration (Table 1).

In the international yield nursery trials, 72 entries were tested in three nurseries during the wet season. Fourteen short duration and 13 medium duration varieties were selected on the basis of high-yielding potential (Table 2).

The yield trials were conducted in the wet and hot dry seasons. Varieties tested in the hot dry season had slow growth at the early stages in mid-February due to low temperatures. The flowering stage coincided with the arrival of the harmattan and high temperatures above 35%C which caused severe sterility. ITA 123 which performed very well in the wet season was severely affected by the unfavourable climate in the hot dry season with a sterility level of 50%. In the wet season, IR13429-126-3 and ITA 123 gave yields of 8417 and 7147 kg/ha respectively; the check variety, I Kong Pao gave 5448 kg/ha.

The coordinated trials were conducted in four places, namely Sapu (Gambia), Djibelor and Fanaye (Senegal) and Contubuel (Guinea Bissau). The varieties which performed well at Fanaye are shown in Table 3. The best varieties will be selected for on-farm verification trials in the next season.

Soil Management

Azolla and Sesbania Research

West African soils are generally poor in organic matter content and nitrogen, while having a high phosphorus-fixing capacity. The improvement of most soils requires high doses of mineral fertilizer which are generally not within the financial reach of rice farmers in West Africa. The integrated soil management program emphasizes organic fertilizers as substitues for for or supplement to mineral fertilizers. In this connections, Azolla research is receiving the most attention. In 1986, Azolla research activities focussed on: (i) screening of Azolla strains in different West African ecological zones in Senegal, Sierra Leone, Mali, Guinea Bissau and Burkina Faso; (ii) Study of alternative sources of phosphorus for Azolla growth and rice yield; (iii) evaluation of mineral nitrogen/Azolla interaction; (iv) Continuation of the INSFER trials and (v) on-farm verification trials. The specific experiments and studies conducted with Azolla and Sesbania are discussed in several paragraphs below.

Table 1. Performance of Varieties Selected in the Observational Yield Trials at Fanaye, Senegal

Varieties	Yield kg ha^{-1}	Height cm	Duration Days
I Kong Pao	6662	91	107
IR 3941-86-2-2-1	6192	90	107
H P U 741	6114	91	101
AIWU	5801	77	100
IR 9729-67-3	5761	90	107
T K M 9	5644	80	106
Chianung Sen Yu	5487	80	107
IR 19728-9-3-2-1	5448	83	99
K 8 8	5409	79	107
IR 3941-25-1	5369	91	106

Table 2. Performance of Varieties Selected in International Yield Nursery Trials.

Varieties	Yield (kg/ha)	Plant Height (cm)	Duration (Days)
	SHORT DURATION		
IR 50	6798	74	111
I KONG PAO (t	6627	82	108
IR 25884-94-3-2	6456	87	106
IR 25670-15-2-3	6371	94	106
IR 28128-45-2	6302	83	104
PND 160-2-1	6200	93	104
UPR 103-80-1-2	6152	79	106
IR 32429-47-3-2-2	6024	81	110
IR 25885-7-3-1	5977	79	107
UPR 231-28-1-2	5925	84	106
TNAU 9039-14	5889	84	112
PND 209-1-2	5801	92	108
TKM 9	5757	83	108
	MEDIUM DURATION		
IR 29658-69-2-1	8008	76	108
I Kong Pao (check)	7805	79	111
AD 9246	7724	87	106
UPL R1-4	7083	75	112
IR 25621-135-1-1	6957	92	107
IR 13240-108-2-2-3	6956	76	111
SKL 17-67-11	6740	79	114
S 28b-39-1-3	6704	87	111
Bi pi 692033	6675	82	114
IR 29692-99-3-2-1	6657	87	106
IR 13524-21-2-3-3-2-2	6638	79	109
IR 31868-64-2-3-3-3	6589	85	111
Chianung Sen Yu 26	6525	109	127

Table 3. Yield and Agronomic Characteristics of some Varieties in the Coordinated Trials at Fanaye, Senegal

Varieties	Yield (kg/ha)	Height (CM)	Duration (DAYS)
	SHORT DURATION		
PR 81-104-1	5841 a	82	125
IR 13540-56-3-2-1	5599 b	84	118
PR 25925-84-3-2	5301 ab	79	104
IR 9698-16-3-3-2	5286 ab	82	106
IR 25840-64-1-3	5222 ab	97	101
BG 276-5	5129 ab	92	101
UPR 307-7-1-1	5028 b	82	102
KAOSHUNG SEN YU 285	4988 b	90	106
TOS	4952 b	73	105
I Kong Pao	4885 b	81	110
	MEDIUM DURATION		
UP 254-85-1 - TAC 3	6965	89	127
IR 25560-132-2-3	5998	116	132
R N R 74802	5624	105	129
JAYA (check)	5430	93	126
ITA 212	5392	86	132
AD 9246	5361	91	123
IR 22082-41-2	5291	101	125
IR 19672-140-2-3-2-2	5239	101	132

For short duration varieties, CV (%) = 10.8
For medium duration varieties, CV (%) = 14 and LSD (0.05) = 1080

Evaluation of the Effects of the Method of Applying Two Sources of Phosphorus on the Growth of Two Species of Azolla and on the Development and Yield of Irrigated Rice

Phosphorus is the most important mineral for the growth of Azolla and for its nitrogenizing activity. In 1984, the effectiveness of two sources of phosphorus, namely, triple superphosphate (TSP) and Thies phosphate (Phospal) on Azolla growth was evaluated at Fanaye, Senegal. Also evaluated at the same place was the effectiveness of basal and split applications of each source of phosphorus on Azolla growth and on development and yield of rice plant. The behaviour of two promising Azolla species subjected to the different treatments was compared. The trials were conducted in two stages: In the first stage, phosphorus from the two different sources was applied in single and split doses and their productivity recorded periodically over a period of eight weeks. In the experiment, ADUL 07 Pi and ADUL 69 Mi strains of A. pinnata var. imbricata, and A. microphylla that had been previously placed under phosphorus deficient conditions were inoculated in a paddy field with 0.3 kg/m2. A total dose of 15 kg P2O5/ha single crop in the

form of triple superphosphate (TSP: 45% P_2O_5) or of Thies phosphate (Phospal: 34% P_2O_5) were applied either once on the day of inoculation or in 3 doses of 5 kg over three days.

After each plot had been completely covered by Azolla, its fresh weight was measured, the initial dose inoculated again and the phosphorus applied in the same way as with the previous single crop. After 8 weeks, the second crop was incorporated into the paddy field soil before rice transplanting. In the second stage of the experiment, Bri Malaysia variety was transplanted at a spacing of 20 x 20 cm using the split plot design replicated twice with the Azolla variety as a main plot, and the source and method of phosphorus application as sub plots. All the treatments received 30 kg N/ha in the form of urea and 60 kg K_2O/ha in the form of potassium chloride as basal application; then 30 kg N/ha each time at the beginning of the tillering phase and at panicle initiation.

The results of the different sources of phosphorus and mode of application on Azolla productivity are shown in Table 4. Azolla growth is greatly affected by phosphorus. There are no differences in the two Azolla strains involved either in terms of phosphorus source or in terms of method of application even though it is noted that A. microphylla has slightly higher productivity with TSP and A. pinnata with Phosphal.

Table 4: Effect of mode of application of triple superphosphate (TSP : 45 P_2O_5) and of Thies aluminium phosphate (phospal: 34% P_2O_5) on the production of Azolla Pinnata VAR. Imbricata (ADUL 07 P1) and of Azolla Microphylla (ADUL 69 Mi) (Fanaye, 1986)

PHOSPHORUS SOURCE	AZOLLA PINNATA		AZOLLA MICROPHYLLA	
	No. of crops (1)	Total biomass produced (1) (T. ha-1)	No. of crops (1)	Total biomass produced (1) (T. ha-1)
Basal T S P	5	81.4	5	92.6
Split T S P	5	90.6	6	101.9
Basal Phosphal	1	22.3	1	15.4
Split Phosphal	2	30.0	1	15.4

F Test Azolla variety (a)	0.26 N.S.
F Test Phosphorus treatment (b)	34.46**
C.V. (a)	23.72%
C.V. (b)	30.49%
S.E. (a)	7.526 tonnes/ha
S.E. (b)	9.523 tonnes/ha

(1) Average of three replications after 8 seasons.

The positive effect of phosphorus on Azolla growth was vident and there was no significant difference in effect due o either phosphorus source or method of application. However, . microphylla showed higher productivity with TSP and A. pinnata ith phosphal, but generally, TSP was more efficient than hosphal for Azolla growth. With regard to rice yield, no ignificant yield difference was observed in relation to the ource of phosphorus applied to Azolla strains before ncorporating it into the soil.

ffect of Azolla on the Response of Two Irrigated Rice Varieties o the Application of Increasing Doses of Mineral Nitrogen

Previous results had shown that it is possible to reduce the pplication of fertilizer by half by incorporating two Azolla rops (40 tonnes per hectare) supplemented by split application f 60 kg N (Urea) per hectare. This combination has resulted in ields of about 7 to 8 tonnes of paddy per hectare. However, aking into account present constraints, namely the availability f water in the Senegal River Valley, the trial was conducted to valuate the impact of a single Azolla crop combined with ncreasing doses of mineral nitrogen.

Since it is known that the response to nitrogen is a rice arietal characteristic, it was deemed expedient to compare two arieties, I Kong Pao, which is already widely grown in the enegal River Valley, and Sri Malaysia which is at the pre-xtension stage.

The two rice varieties were transplanted at 20 x 20 cm pacing, using the split plot experimental design with three eplications. The rice varieties were planted in the main plot, he sub plot with or without Azolla incorporation and the sub lots with mineral nitrogen (urea) doses at the rates of 0 (zero) 0, 60 and 90 units. In the sub plots, one Azolla pinnata var. mbricata ADUL 07 pl (20 t/ha) was either incorporated before ransplanting or grown as an associated crop with rice. The ineral nitrogen was applied the day before transplanting (50%) t the beginning of tillering (25%) and at panicle initiation 25%). All the plots received the basal application of 60 kg $2O_5$ and 60 kg K_2O per hectare in the form of triple uperphosphate and potassium chloride.

The results shown in Table 5 indicate that rice yields ncrease with increasing doses of mineral nitrogen. The yield of Kong Pao was generally lower than that of Sri Malaysia which esponded better to nitrogeneous fertilizer application. The resence of Azolla whether or not it is incorporated affects ield. At the rate of 30 and 60 kg N, Azolla incorporated nhances the efficiency of mineral fertilizer, especially in the ase of I Kong Pao.

Table 5 : Effect of one Azolla crop on grain yield of two varieties of irrigated rice with increasing doses of mineral nitrogen

(FANAYE, WET SEASON 1986)

Mineral Nitrogen (Kg.ha-1)	I Kong Pao			Bri Malaysia		
	Without Azolla	Associated Crop	Azolla incorporated	Without Azolla	Associated Crop	Azolla incorporated
N0	2974	2757	3559	3899	5310	5055
N30	3121	3967	5932	6271	5972	7334
N60	4970	5495	6907	5953	6908	7445
N90	6948	7964	7854	7991	7476	7608
Average	4503	5046	6038	6028	6391	6360

F Test Variety (a)	26.2*		
F Test Nitrogen (b)	91.2**	CV. (a) :	19.1%
F Test Nitrogen (c)	33.5**		
F Test Variety x Nitrogen	6.0**	CV. (b) :	4.3%
F Test Variety x Azolla	3.6 NS		
F Test Nitrogen x Azolla	2.7*	CV. (c) :	8.5%
F Test Variety x Nitrogen x Azolla	1.NS		

Effect of Azolla on Irrigated Rice Yield (INSFER Trial)

This trial, conducted during the hot dry and wet seasons in 1986, was conducted in collaboration with IRRI within the framework of INSFER trials. The aim was to compare the effects of Azolla and mineral fertilizer (urea) and also to determine the best method and period of applying organic fertilizer.

Bri Malaysia variety selected for the trial was transplanted at a spacing of 20 x 20 cm using Randomized Complete Block design (RCB) with 8 treatments and 4 replications. The treatments included 30 and 60 kg N per hectare in a simple or split dose in the presence or absence of Azolla. With the exception of treatment in which it was applied in situ before and after transplanting, Azolla was produced outside the paddy field and directly incorporated at the rate of 15 tonnes of fresh matter per hectare before or after transplanting.

The results presented in Table 9 indicate a significantly great effect of treatments during the two seasons. The best

yield was obtained with successive incorporation of 15 tonnes of Azolla before transplanting and of 15 tonnes twice 16 and 31 days after transplanting.

The basal application of the entire mineral fertilizer dose according to the standard protocol caused nitrogen losses which resulted in yield losses which were not as high as one Azolla crop was incorporated before or after transplanting.

Influence of Sowing Date and Sesbania rostrata Incorporation on Irrigated Rice Yield

The wild legume Sesbania rostrata which is very common in the Senegal River Valley constitutes another promising alternative to chemical nitrogeneous fertilizer. In general, most legumes have nitrogen-fixing nodes in their roots. Sesbania rostrata has these nodes both on its roots and stems with the result that it has a very high nitrogen accumulation potential that can reach 200 kg N per hectare per cropping season. Preliminary trials at the station showed that Sesbania rostrata incorporation before rice transplanting could result in saving up to 75% of the recommended nitrogen dose for the region. There are, however, a number of factors that must be resolved before it can be successfully introduced on farmers' fields. Among these are the determination of the best date and method of growing Sesbania, the method of inoculating Rhizobium in the field, problems related to the rice and Sesbania cropping calendar as well as the problem of green fertilizer incorporation.

Table 6 : Comparative effects of urea and Azolla Pinnata VAR. Imbricata on Grain Yield of Sri Malaysia (Fanaye, 1986)

TREATMENTS	1986 Dry Season		1986 Wet Season	
	Kg.ha-1	Index	Kg.ha-1	Index
N0	3630 bc(1)	100	2865 d(1)	100
N30 (basal)	3239 c	89	3014 cd	105
N30 + turning of the soil 3 WAT (2)	4255 bc	117	3650 bc	127
N60 (3 applications)	4670 b	129	3634 bc	127
N30 (basal) + 15 tonnes Azolla DA (3) before transplanting	4331 b	119	4087 ab	143
N30 (basal) + 15 tonnes Azolla DA 3 WAT	4616 b	127	3287 bcd	115
N30 (basal) + 15 tonnes Azolla 3 not incorporated 3 WAT	4518 b	124	3203 cd	112
Azolla before and after transplanting (4)	5967 a	164	4453 a	155
F (Treatment)	4.90**		7.76**	
CV. (%)	16.50		14.10	
SE	364.00 kg		249.00 kg	

1. In the same column, figures followed by the same letters are not different at 5%.
2. WAT : Weeks after transplanting
3. DA : Direct application. Azolla is multiplied outside the paddy field and directly incorporated before transplanting.
4. 1 crop before transplanting and 2 crops after transplanting, representing 45 tonnes incorporated.

The aim of this trial, first conducted in 1985 with the collaboration of ORSTOM in Dakar, was to determine the best period for Sesbania rostrata establishment and incorporation before sowing wet season rice. The experimental design was the split plot replicated four times with Sesbania sowing dates as the main plot (10 April, 8 May, 5 June, 3 July) and the presence or absence of Sesbania in the sub plots. Sesbania was sown at the rate of 40 kg/ha by broadcast after pre-treating it with sulphuric acid and applying 30 kg P_2O_5/ha in the form of Matam phosphate in all the plots. Inoculation was with Rhizobium powder 3 to 7 weeks after sowing by spraying the stems. Cutting and incorporating Sesbania was carried out 9 weeks after sowing, and the IKP variety was replicated 2 weeks after incorporation. Supplementary application of 30 kg N/ha in the form of urea was undertaken 20 days after transplanting.

The results of the experiments presented in Table 7 confirmed the previous year's results, that is, yields are greatly affected by sowing date and incorporation of Sesbania rostrata. The best dates for sowing and incorporation of Sesbania were 5 June and 6 August respectively.

Water Management

The Water Management Project was launched in 1982 with the financial assistance of the Dutch Ministry of Foreign Affairs, Department of International Cooperation (DGIS) - with the Department of Irrigation and Civil Engineering of the Agricultural University of Wageningen providing scientific supervision. The West Africa Rice Development Association is responsible for its execution. The Project has two research phases. In the first phase which lasted for 2 years, from 1982 to 1984, a study of irrigated water management in several small villages was undertaken in order to observe and evaluate the status of irrigated water management in Senegal. The second phase which began in November 1985 and will end in May 1989 focuses on the completion of activities of development companies and farmer groups in the area of applied research, technical and socio-economic assistance to small-scale irrigation agriculture and design of new forms of irrigation. Its ultimate aim will be to design a research methodology applicable to the entire subregion.

Table 7 : Effect of the sowing date of Sesbania rostrata on irrigated rice yield (Fanaye, 1986 wet season)

Sowing date of Sesbania rostrata	With Sesbania rostrata Grain yield (Kg.ha-1)	Without Sesbania rostrata Grain yield (Kg.ha-1)
10 April 1986	3521	2693
8 May 1986	5929	4465
5 June 1986	7756	5389
3 July 1986	6017	5553

F Test

sowing date	23.47**
Sesbania treatment	123.86**
Sowing date x Sesbania treatment	13.29**
CV (a)	16.77
CV (b)	6.28
SE (Kg/ha) Sowing date	433.013
SE (Kg/ha) Sesbania treatment	162.018

Development of Village Irrigated Plots (PIV)

In 1986, a study was conducted on development of small village irrigated plots which will emphasize technical and socio-economic aspects of water management. The study showed that the water management problems range from purely technical, economic and social issues to organizational issues which call for a design of an inter-disciplinary scientific research programme.

In 1986, other studies were conducted to provide a better understanding of the problems of water management in the Sahel zone. The studies were carried out in three Mauritanian villages (Gani, Medina/Gaya, Malaiga), four villages in the Podor Region in Senegal (Bakel/Matam - Moudery, Dembankane, Gassambilakh and Guia IV), and also the Ronkh Home and the Donaye village in the Middle Valley and the Delta area of Senegal River Valley. The studies were carried out in collaboration with the Agricultural University of Wageningen, University of Leiden, National Rural Development Institute and the Institute of Environmental Science in Senegal.

Basin Development

A study of small-scale plots is deemed important since it is at this level that actual development takes place and under farmer management. However, the options of member governments of OMVS have led the Saint Louis Station to broaden the scope of its research activities and to direct some to basin development. This new orientation requires that the problem of managing these large entities be reviewed in line with the social organisation of producers.

The research activities are limited to basins selected on the basis of technical and socio-economic interest. The current research focuses on the applicability of operating principles of the PIVs to the basin areas. It is also emphasizing (i) selection of sites to be developed which involves studies of land tenure systems and existing socio-cultural relations and (ii) the design of new irrigation networks and their organisation, etc. In 1986, two basins were selected for study.

In cooperation with the Dutch Mission based in Cascas, socio-economic studies were conducted there. In the Nianga basin, the studies focused on restructuring producer groups into GUMA and follow-up of GUIA 4 farmers (PIV) who were living in what is a large irrigation network and a PIV.

Another trial was conducted on an intermediate network at Donaye by an ISRA researcher-in-training in the field of rural engineering. The sociologist who has already undertaken some socio-economic surveys will then complete the study. The study of the Cascas basin has already produced information on land tenure problems and the choice of crops.

The preliminary phase of the project has made it possible to establish a fairly comprehensive data bank on (i) technical characteristics, (ii) the state of the irrigation network, (iii) the functioning of the infrastructure, (iv) the organisation of irrigation, (v) water management, (vi) general management of the plot and (vii) water needs and requirements.

III. Diseases and Insect Pests

Diseases and insect pests seriously affect the performance of rice grown under irrigation. Studies on the incidence of rice diseases in Senegal started in 1984. The studies so far show that the incidence of disease is higher in the wet season. The diseases identified and the extent of their incidence are shown in Table 8. The 1985 rainy season was quite wet, thus creating favourable conditions for the outbreak of diseases. In 1986,

there was less pressure of diseases in the Senegal River Valley whereas the pressure was much greater in Casamance which is in a wetter zone.

Pathogenic Variations on Xanthomonas Campestris p.v. Oryzae

In 1985, a study was initiated on the possible outbreak of the different virulent pathogenic groups of Xanthomonas campestris p.v. Oryzae and to identify the predominant pathotypes in the ecosystem.

Certain varieties that are well known for their resistance to certain pathotypes in the Philippines as well as varieties whose reactions are well known in West Africa were used with high doses of nitrogen (150 kg N/ha) to create conducive conditions for the development of the pathogen. The inoculum was taken from the leaves of 4 infested varieties to inoculate 10 varieties of 5 response groups ranging from very resistant to very susceptible. 30-day old seedlings were inoculated and their incidence evaluated 21 days after inoculation.

Table 8: Incidence of Diseases in Senegal

	Senegal River Valley			Senegal
	1984	1985	1986	1985
Blast	++	++	+	++
Brown leaf disease				
Sheath blight	-	+	+-	++
Bacterial leaf blight	+	++	+	-
Rice yellow mottle	-	-	-	+

(-) (+) (++) severe (+-) moderate

The results are presented in Table 9 and illustrated in Figure 1. The inoculum obtained from varieties with moderate resistance such as Kwang She Sung and I Kong Pao was more virulent on all the varieties except CAS 209. Kung She Shung gave the most virulent inoculum followed by I Kong Pao. The inoculum obtained from IR 8 and TN 1 was not virulent on all the moderate virulent resistant varieties on those that are susceptible (Fig. 2).

It was noted that there is a great difference in virulence between the inoculum obtained from the group of varieties with moderate resistance and those from the susceptible varieties. The inoculum obtained from the susceptible varieties is very virulent and that from the group of varieties with moderate resistance has low virulence (Table 10, Fig. 3).

ode of Infection of Xanthomonas campestris p.v. oryae

The purpose of this study was to observe the degree of nfection of inoculated leaves through mechanical lesions. Two arieties, I Kong Pao (resistant) and TN 1 (susceptible) were sed. The inoculum which was obtained from IR 8 was prepared at ifferent times after lesion appearance at 5, 30, 80 minutes and 4 hours. The evaluation of the lesions caused by the disease as undertaken 14 days after treatment. The most severe nfection was observed, in a decreasing order, on leaves noculated 5, 30, 80 minutes after the appearance of lesions.

ffect of Different Sowing Dates on the Incidence of Bacterial af Blight

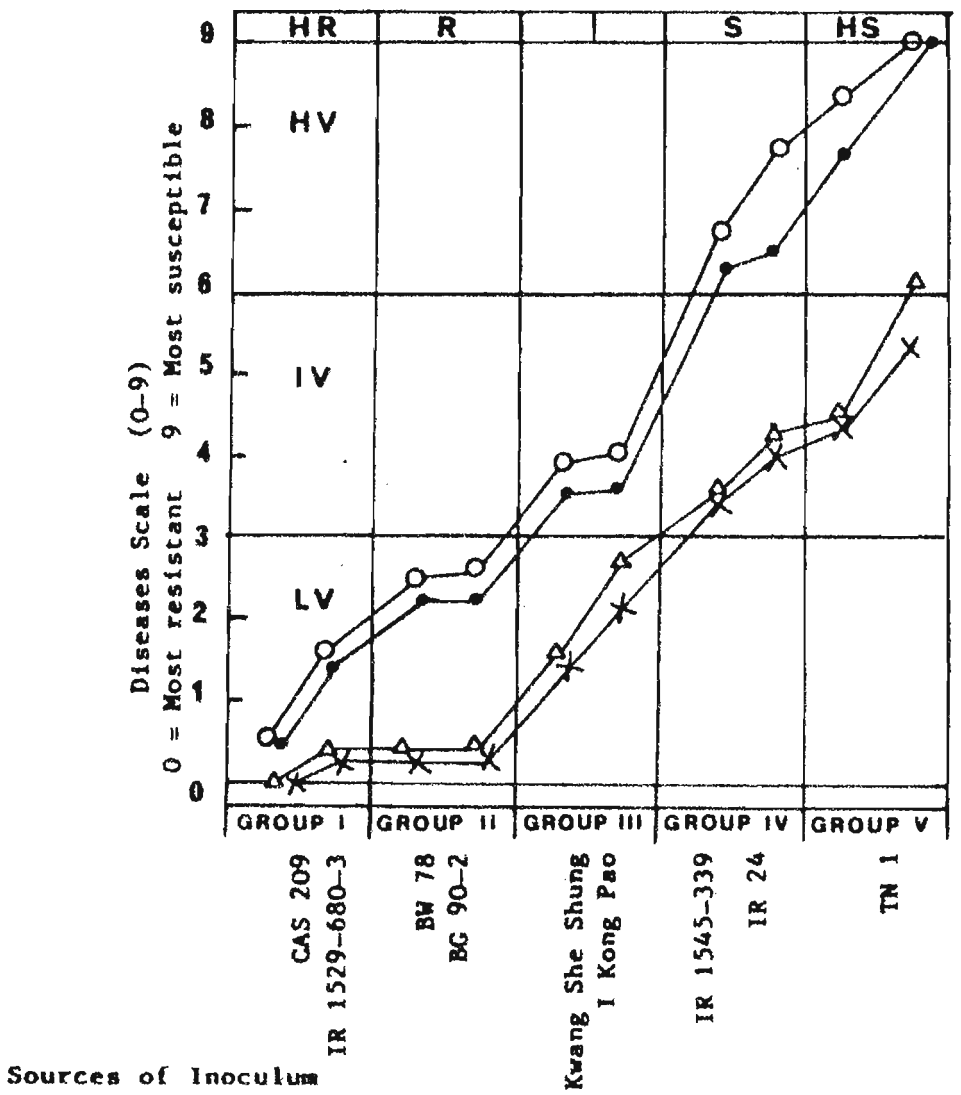
To study this, three varieties with different reactions were sed, namely BG 90-2, I Kong Pao and TN1 (susceptible). Sowing as staggered as follows: 7 and 21 July, 5 and 19 August and 2 nd 16 September. NPK was applied at a rate of 120-60-60 kg/ha. ll varieties sown after July were severely attacked, and TN1 was ie most seriously affected (Table 11).

able 9: Reaction of rice to inoculum sources of Xanthomonas campestris p.v. Oryzae in Northern Senegal

epresentative arieties	Source of Inoculum* Inoculum 1	Inoculum 2	Inoculum 3	Inoculum 4
R 209	0.3	0.2	0	0
1529-680-3	1.5	1.3	0.3	0.2
78	2.5	2.3	0.2	0.2
90-2	2.5	2.2	0.3	0.2
ang She Sung	3.8	3.6	1.4	1.3
Kong Pao	4.0	3.6	2.6	2.0
1545-339	6.5	6.2	3.3	3.2
24	7.8	6.3	4.3	3.8
9782-144-3-3-3	8.5	7.8	4.5	4.2
1	9.0	9.0	6.3	4.5

noculum 1-4 obtained from the varieties given in the Table.

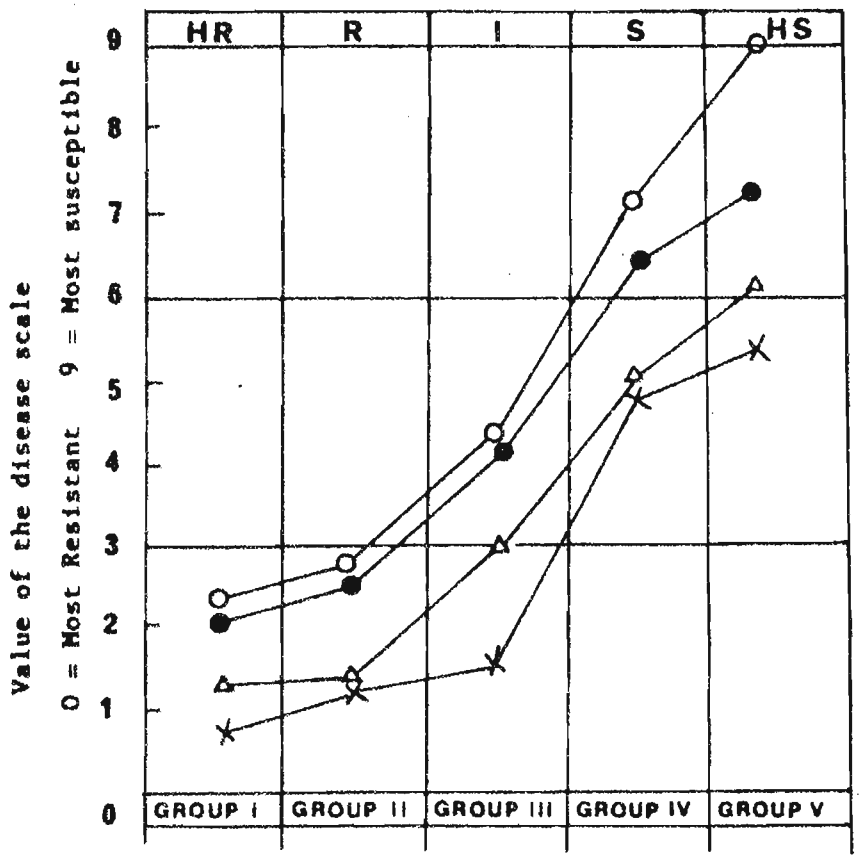
Fig.1 : Type of virulence shown by 4 sources of inoculum from the pathogen bacteria on 10 representative varieties of 5 groups with variable reaction.



(1) Horizontal column = Level of path virulence of

(2) Vertical column = Differential to 4 inoculu

Fig. 2 : Interaction of bacteria-host between selected representative varieties and 4 sources of inoculum applied to the KSS



Legend

Kwang She Shung ----Kwang She Shung -- Representative varieties

I Kong Pao ----Kwang She Shung -- Representative varieties

IR 8 ------ ------- Kwang She Shung -- Representative varieties

TN 1 ---------- Kwang She Shung -- Representative varieties

Table 10: Type of virulence shown by 4 sources of inoculum applied to KSS to 5 representative varieties

Variety/ Line	Group	Inoculum of 4 Sources through KSS							
		Inoculum 1 Point	Reac- tion (2)	Inoculum 2 Point	Reac- tion	Inoculum 3 Point	Reac- tion	Inoculum 4 Point	Reac- tion
CAS 209	I	0.8	HR	1.4	HR	2.0	R	2.4	R
BG 90-2	II	1.2	HR	1.5	R	2.6	R	2.8	R
I KONG PAO	III	1.3	R	3.0	R	4.1	MR	4.3	MS
IR 1545-339	IV	4.8	MS	5.2	S	6.5	S	7.2	HS
TN 1	V	5.5	S	6.2	S	7.4	HS	9	HS

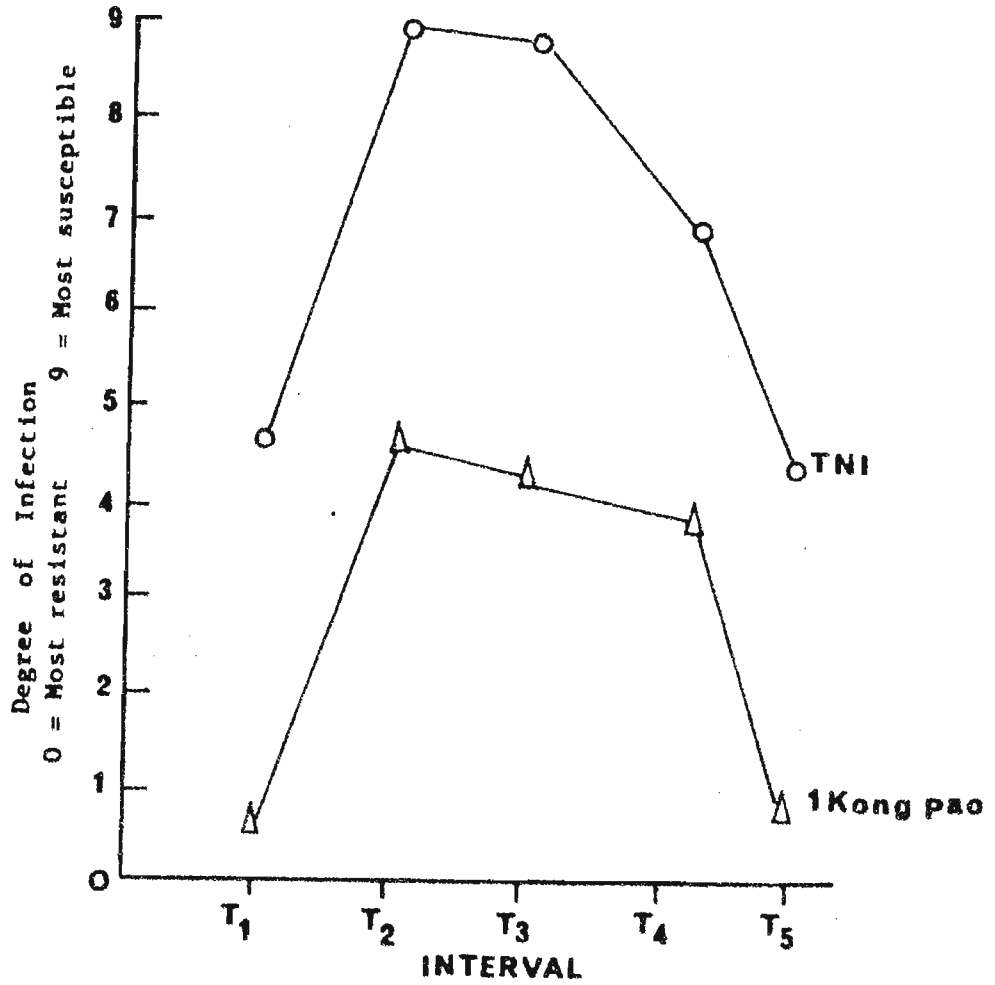
1 = inoculum 1
Inoculum 2
Inoculum 3
Inoculum 4

2 = Mean value for the 10 inoculated leaves/lines

3 = Varietal reaction to the severity of the disease

HR = Highly resistant
R = Resistant
MR = Moderate resistance
S = Susceptible
MS = Moderately susceptible
HS = Highly susceptible

Fig.3 : Level of infection by bacterial leaf blight on two rice varieties.



T_1 = No lesions. Only through pores

T_2 = Inoculation 5 minutes after the appearance of lesions

T_3 = Inoculation 30 minutes after the appearance of lesions

T_4 = Inoculation 80 minutes after the appearance of lesions

T_5 = Inoculation 24 hours after the appearasnce of lesions

Table 11 : Development of bacterial leaf blight and its effects on rice yields

Sowing Date	Varieties	Yield	Variation (1) Scale	
		Kg ha-1	Kr	FF
7 July	BG 90-2	8200	1.17	1.08
	IKP	6400	1.25	1.43
	TN 1	5800	2.75	3.55
21 July	BG 90-2	8200	1.30	1.18
	IKP	6200	1.40	1.40
	TN 1	5600	2.75	3.40
5 August	BG 90-2	8000	2.33	2.38
	IKP	6000	2.78	2.80
	TN 1	5500	3.20	3.68
19 August	BG 90-2	7800	2.38	2.45
	IKP	4700	4.35	5.00
	TN 1	4200	6.85	6.63
2 September	BG 90-2	7500	2.50	2.48
	IKP	3900	5.28	5.98
	TN 1	3700	7.43	7.48
16 September	BG 90-2	6700	2.60	2.60
	IKP	3800	5.48	6.20
	TN 1	3400	7.83	8.03

(1) Kr = Kresek FF = Bacterial leaf blast

IV. On-farm Trials

In 1986, several on-farm trials were conducted in Senegal to determine the performance of some technologies on farmers' fields.

Matam Phosphates Trials

In a bid to replace some of the imported inputs by locally available sources, trials were conducted on Matam phosphate which can be used directly in its raw form to replace triple superphosphate or ammonium phosphate in rice production. Four trials to determine the best mode of application were conducted in two locations and on three representative valley soils. Since this phosphate has a major residual effect, this was tested as well with respect to frequency of application. The experimental design was the Randomized Complete Block design (RCB) with 4 replications. Each sub plot had an area of 25m2. The results available from only one trial and presented in Table 12 indicate that Matam phosphate could be used as an alternative for TSP and that farmers are very interested in the positive residual effect.

Effect of Azolla Compost on Irrigated Rice Yield

It is possible to produce Azolla in great quantities by using the ponds and drains that exist in irrigated plots. If grown under favourable conditions, an Azolla strain that is well adapted can be very productive in a relatively short time (doubling of biomass between 3 and 4 days). The biomass contains much nitrogen (3.5-4.0% of dry weight) and can make up for the lack of straw usually noted in farmers' fields. If regularly harvested and placed in heaps for composting and spread on the rice soil before ploughing, the biomass could be useful in organic soil improvement while offering another alternative to the agronomic use of Azolla.

A study of the effectiveness of Azolla compost on rice yield which was first conducted in 1985 was repeated in 1986. The experimental design was the Randomized Complete Block design (RCB) with 3 replications. The plots had an area of 100m2, and the treatments are indicated in Table 13. The results of the trials are presented in Table 14. All the treatments were significantly different in the second year. The best treatment was obtained by the combination of 60N + 15 tonnes. It is nevertheless premature to conclude that this increase in yield can be completely attributed to the compost because the phosphate fertilizer dose was less on the farmer T2 treatment.

Table 12 : Effect of the Application of Matam phosphate on rice yield JAYA Variety (Second Season - Matam Trial Location)

Treatment P2O5			
Kg/ha	Form	Frequency of Application	Yield (Kg/ha)
0			5550 c
60	TSP	Each cropping season	8988 a(1)
60	Matam Phosphate	Each cropping season	7025 b
120	Matam Phosphate	Each cropping season	9100 a
120	Matam Phosphate	2 seasons	9425 a
120	Matam Phosphate	4 seasons	9315 a

(1) Yields followed by the same figure are not different (P.0.05)

Table 13. Treatment of Azolla Compost Trial at Nianga (1985 and 1986)

	1985 Wet Season			1986 Wet Season		
	N	Compost	P2O5	N	Compost	P2O5
	(kg.ha^{-1})	(T.ha^{-1})	(kg.ha^{-1})	(Kg.ha^{-1})	(T.ha^{-1})	(kg.ha
T1	0	0	60	0	0	60
T2 (farmer)	70	0	12	72	0	23
T3	60	10	60	60	15	60

Table 14: Effect of Azolla compost on the yield of the JAYA variety at Nianga (1985 and 1986)

Treatment	1985	1986
T1	4270 b (1)	4383 c (1)
T2	6171 a	5533 b
T3	5848 a	6333 a
LSD 0.05	1459	793
CV %	11.86	6.46

(1) The averages followed by the same letter are not significantly different at the level of 5%

Testing of the IRRI TR 4 Mechanical Transplanter (6 rows) at Fanaye - Hot Dry Season (1986)

In the hot dry season of 1986, the performance and operational cost of the TR 4 transplanter designed by IRRI and manufactured locally were assessed.

Tested alongside the mechanical transplanter (T1) was a manual transplanter, (T2). The tests were replicated twice on sub plots of 10 hectares each. The results of the tests are presented in Table 15. The net time taken by the mechanical transplanter (about 9 hectares/day/ha) was much less than that of the manual transplanter (44 hours/day/ha). The reduction in work time was about 80%. However, work stoppage time was greater in the case of the mechanical transplanter due mainly to time taken to resupply the nursery. The work stoppage in the case of the mechanical transplanter can also be attributed to the lack of adequate knowledge about the equipment which was being tested for the first time. Table 16 gives the expenses related to the transplanters. The total expenses for the manual transplanter is more than double that of the mechanical transplanter.

Comparative Study of the Modified DAPOG and Traditional Nurseries

The aim of the trial which was conducted in two villages in the Senegal River Valley was to confirm the results of previous years. The trial was of the dispersed type with 10 farmers (replications) and two treatments (traditional nursery). The results of the trial were consistent with those of the previous seasons. The Dapog method gave a yield increase of about 36%, the duration of the nursery was reduced by 30 days on the average and there was a substantial reduction in the area of the nursery. Farmers continued to show interest in the Dapog nursery as several Dapog nurseries were set up in small irrigated plots and homes in 1986. Farmers mentioned the following among reasons why they prefer the Dapog method: (i) good seedling recovery, (ii) good tillering capacity, (iii) savings of gas oil and manpower and (iv) high yields.

Table 15: Performance of Mechanical and Manual Transplanters in Senegal, 1986

Transplanter	Hours/ha	Approx. Day/ha.
Mechanical	70	9
Manual	352	44

Table 16: Operating Costs of mechanical and manual transplanters (CFA/Ha)

Source of Cost	Mechanical Transplanter	Manual Transplanter
Depreciation	13,000	-
Labour cost	15,470	67,642
Maintenance/Repairs	2,600	-
Total Operating Cost	31,070	67,642

GERMPLASM UNIT

In 1986, over 300 accessions were added to the germplasm bank. The accessions originated from Burkina Faso and Asian countries.

Some 543 local cultivars from Sierra Leone, and some West African collections obtained through IRAT in France were characterized at Suakoko in Liberia.

Thirty four of the accessions (Table 1), screened for tolerance to iron toxicity, had scores of 0 or 1 at 4 and 8 weeks after transplanting indicating tolerance. These will be further screened in the concrete bed and in the field to confirm their tolerance to iron toxicity.

Furthermore, viability tests were conducted on 1801 accessions in the germplasm bank and on another 221 varieties in the Seed Laboratory destined for either the germplasm bank or for other users.

543 accessions with low germination were seed increased at Suakoko while for accessions that had nil germination arrangements were made to obtain new supplies through the original source.

Based on request, a total of 146 entries in the germplasm bank were dispatched to several scientists in Liberia, Malawi, Nigeria and Uganda. Also, at the request of the Post-harvest Technology Unit, 3.4 tonnes seed were produced from ten varieties.

Table 1. Accessions showing tolerance to iron toxicity in bucket experiments, Suakoko. Main Season, 1986.

ACCESSION NO	CULTIVAR	ACCESSION No	CULTIVAR
913	Yanssinah 19	1136	Pa Momoh Kamara 22
895	Pa Bintu IIA	1158	Banjul BaI 384
908	Cobui 190	1101	Pa Soro 125
1003	Pa Konday 241	1120	Pa Fant 213
1177	Pa Bundu 62	1023	Kiti Mano 368
1590	Ys 441	1029	Pa Rooko 271
1592	Ys 429	1034	Pa Mayaninie
1130	Pa Tok 278 A	1041	P.C. Wui 297
906	Pa Bai Tollie	991	Pa Bia Bureh
889	Pa Ronko 54A	1044	SAmba 327
881	Pa Soro Kent 228	1046	Nyabo II 421
880	Pa Bundu 328	1115	Pa Sanasi 219
871	Pa Lamina 220	1013	Mani Fingo 456
863	Mathes 129	1006	Kumba Mano 380
832	Morasan 109A	1102	Cherno 391
1107	Sawani 217		
998	Kpeyei 192		
1172	Gbondo Yakei 290		
1150	Alma Koyo I 417		

INTERNATIONAL RICE TESTING PROGRAM (IRTP)

In collaboration with other institutes, WARDA participated actively in the various aspects of IRTP-Africa and IRTP Global. WARDA was responsible for the distribution of most of the nurseries in the WARDA region. The collection and transmission of trial data was done by WARDA for most of the trials.

WARDA Headquarters' staff conducted three upland and three irrigated trials at Suakoko for the IRTP-Africa. In the IRTP-Global, an acid lowland screening set was also conducted at Suakoko, Liberia. Results of all the trials have been sent to the Coordinators at IITA and IRRI for joint reporting.

IRON TOXICITY RESEARCH

The iron-toxicity research program conducted in collaboration with IITA and the Central Agricultural Research Institute (CARI) of Liberia continued in 1986.

Highlights of the activities and some results are given below.

1. Development of reliable screening methodology

Three methodologies (Pot, Concrete bed and Field) were evaluated and utilized for screening and conducting some special trials.

To evaluate the reliability of the three methods, seven cultivars of varying levels of tolerance to iron toxicity were used. IR 26 was used as the susceptible check and Suakoko 8 as the resistant check. The seedlings for the trials were sown on June 2, 1986.

Toxicity scores based on a scale of 1-9 were taken at four and eight weeks after transplanting (WAT)

1 = Growth and tillering nearly normal
9 = Almost all plants dead or dying.

The results for 8 WAT are shown in Table 2.

As shown in Table 2, the comparative performance of the cultivars under the three screening conditions confirms the reliability of the three screening methodologies. Under the three conditions, all the tolerant entries and Suakoko 8 scored between 1 and 4 as would be expected. The pot method had the lowest coefficient of variation (CV) while the conrete bed had the highest CV. The high CV of the latter can be explained by the fact that the concrete bed was newly constructed.

From the results, it can be seen that the three screening methodologies are satisfactory for screening genetic materials for tolerance to iron toxicity. The choice of any of them depends on the type of experiments and the amount of seed available. The pot and concrete bed methods should produce more uniformity of toxicity than the field method.

Table 2.

Fe Scores at 8 WAT using Three Screening Methods

	Entry	Pot	Concrete bed	Field
1.	SUAKOKO 8	2.39b	1.96b	1.42c
2.	BISSI 27	2.64b	1.30b	3.22bcd
3.	IR 26	6.29a	6.09a	8.05d
4.	IR 5	2.58b	3.39ab	3.61bc
5.	CIAT 249	2.59b	1.16b	2.45cde
6.	ITA 249	3.07b	2.50b	4.00b
7.	MAT CANDU	2.39b	2.56b	1.88dc
	C.V.	17.07	38.32	24.15

2. Identification of cultivars tolerant to iron-toxicity

From the WARDA germplasm bank, 249 accessions were screened and thirty four were found to be tolerant. About 20 entries from the 180 cultivars on the IRTP-Global set were tolerant. Out of the 12 fixed lines from the WARDA Station at Rokupr, two lines : WAR 87-1-M1-1 and WAR 35-36-2-1-1 were tolerant.

3. Root and shoot growth and development under iron toxic conditions

The purpose of the root trial was to find out how the roots of different cultivars are affected by iron toxicity.

Seven cultivars (Table 3) with different levels of tolerance were used for this study. The pot screening method was used. Characters were studied at 4, 6, and 8 weeks after transplanting (WAT) into toxic and non-toxic pots. In this report, only the results for 8 WAT are presented.

Table 3. Plant height and some root characteristics under toxic and non-toxic pot conditions

ENTRY	non-toxic	Toxic	% diff. non-toxic & toxic	non-toxic	Toxic	% diff. non-toxic & toxic	non-toxic	% diff. non-toxic & toxic	
Suakoko 8	79.33a	61.33ab	23	31.33A	42.67a	27	272.33a	254.67a	6
Gissi 27	81.00a	62.33ab	23	31.33A	38.33b	18	239.33a	239.00a	6
IR 26	74.33ab	40.19e	46	29.67a	14.29e	52	295.67a	61.27b	79
IR 5	68.67bc	54.67cd	20	32.67a	25.67d	18	220.67a	130.67b	41
CIAT21528	68.33bc	52.00d	24	35.67a	29.33cd	18	313.33a	321.67a	-3
ITA 249	64.18c	56.00cb	13	32.35a	30.33c	6	279.03a	243.33a	13
MAT CANDU	76.00ab	67.67a	11	34.67a	30.67c	12	312.33a	266.67a	15

+ Means in the same column followed by the same letter are significantly different at the 5% level of probability (DMRT)

Results of the experiments are shown in Table 3.

a). Plant Height

The highly susceptible entry, IR 26, had 46 % reduction in height under toxic conditions as compared to non-toxic conditions. Mat Candu, a very tolerant cultivar, showed the least effect of iron toxicity on shoot height. The difference was only 11%. The effect of iron toxicity does not follow a clear trend. IR 5 which is moderately tolerant had less height reduction (20%) than Suakoko 8 and Gissi 27 which are highly tolerant cultivars. The differences in their plant types are apparently responsible for this. Tall cultivars such as Suakoko 8 and Gissi 127 are apparently more sensitive to height reduction than short or intermediate cultivars.

b). Root Length

Root length showed interesting reactions. The highly tolerant cultivars, Suakoko 8 and Gissi 27, had longer roots under toxic conditions than under non toxic conditions. While IR 26, a susceptible entry, had 52% root length reduction, tolerant entries such as ITA 249 and Mat Candu had their root lengths only slightly reduced under toxic conditions (6 and 11% respectively). This confirms earlier reports that the roots of tolerant cultivars are able to grow and elongate normally in spite of the toxicity. It may also be stated that rapid root elongation is one of the mechanisms for the tolerance exhibited by some cultivars under toxic conditions.

c) Root Number

The trend in root number approximates that of root length although the reduction for Mat Candu (15%) was higher than expected and CIAT 2158 had 3% more roots under toxic conditions. IR 5, an intermediate cultivar, performed as expected with 41% reduction while the susceptible entry had 79% less roots under toxic conditions. The highly tolerant entries, Suakoko 8 and Gissi 27 each had only 6% reduction in root number.

Thus, the tolerant cultivars in this experiment were able to continue to produce roots with little or no adverse effects by the toxicity. With some caution, one may state that ability to increase in root number is another mechanism for iron toxicity tolerance.

4. Grain yield of identified tolerant cultivars

This trial was conducted to determine the yielding abilities of the identified tolerant cultivars.

The trial was conducted using pots, concrete bed and field conditions with subplots that have toxic and non toxic soil. The six cultivars used were Suakoko 8 (tolerant check), IR 26 (susceptible check which died before maturity), IR 5, CIAT 21528, ITA 249, Mat Candu. Data was collected on many traits. Only height, days to maturity and grain yields are reported for trials conducted under field conditions. The yields were adjusted to 14 % moisture content basis.

Some of the results from the trials are shown in Table 4.

a) Days to Maturity

In the field trial, the cultivars in general matured longer under the toxic conditions than under non-toxic conditions. IR 5 produced the highest difference in this trait than any other entry. The difference was about 19 days.

b) Height

All entries in the field were taller under non toxic than under toxic conditions. This means plant height is reduced by iron toxicity no matter the plant type.

c) Yield

Yield loss under the toxic condition varied from 51-76 per cent. IR 5 had the highest yield reduction both in the field and concrete bed trial. This is expected as IR 5 was the least tolerant of all the surviving entries in the trial.

It is interesting to note the relative high yields of Mat Candu as compared to the tolerant check, Suakoko 8. Under non-toxic soils in both concrete and field conditions, it was significantly higher yielding than Suakoko 8. Under toxic conditions, it was also the highest yielder though not significantly different from the tolerant check. Mat Candu is therefore a very

promising cultivar that could be used as a long duration variety. In some parts of Liberia, it could easily replace the photosensitive Gissi 27. Meanwhile, it is being used as a parent in breeding programs as the height and maturity need to be reduced.

In these trials iron toxicity reduced plant height, lengthened days to maturity and reduced grain yields by 51-76 per cent of tolerant cultivars. Mat Candu is a very promising cultivar. It produced over 1 ton/ha more than Suakoko 8 under non-toxic conditions and 301 kg/ha more than Suakoko 8 under iron toxic conditions. It could be recommended as a variety for inland swamps and as parent for breeding programs.

Table 4. Days to maturity, height and grain yields of 5 tolerant cultivars under toxic and non-toxic conditions in field trials, Suakoko, 1986.

		DAYS TO MATURITY		HEIGHT IN CM		YIELD KG/HA		% YIELD DIFERRENCE BETWEEN-NON TOXIC AND TOXIC
		Nontoxic	Toxic	Nontoxic	Toxic	Nontoxic	Toxic	
1.	Suakoko 8	143.00c	150.00bc	144.67b	112.33a	3332b	1823ab	45
2.	IR 5	142.00c	160.67a	107.33d	75.00b	2841bc	665c	76
3.	CIAT 21528	124.67d	131.33d	104.33d	86.67b	2478c	1010c	59
4.	ITA 249	142.00c	145.02c	116.00c	78.99b	3166bc	1552b	51
5.	Mat Candu	153.33b	156.00ab	153.00a	111.33a	4431a	2124a	52

* = Means in the same column followed by the same letter are not significantly different at the 5% level of probability.

5. Breeding iron toxicity resistant cultivars

a) Hybridation

In 1986, 21 crosses were made for inheritance studies and selection work. Parents involved were Suakoko 8, IR 5, Bissi 27, CIAT 2158, Labelle, IR 26, Mat Candu and ITA 249.

b) Introduced segregating Lines

Three hundred and sixteen segregating lines were introduced from IITA for screening under the iron toxicity conditions. Over two hundred plants with good level of tolerance were selected for further assessment. Some of the lines selected were: TOX 85C-C1-1-WASI, TOX 85C-C1-10-WAS 5, TOX 3107-4-WAS 1, TOX 3118-5-WASI.

Through the shuttle breeding arrangement with IITA, half of all the selected lines were sent to IITA for blast, Rice Yellow mottle virus screening and plant type selection. The promising lines are then sent back to WARDA for further evaluation.

c) Selections from F3 populations

From the original crosses made at Suakoko, a total of 124 lines were selected for further studies.

d) Mutation breeding

Ten mutants and 12 mutants were selected from irradiated Suakoko 8 and ITA 249 respectively.

POST-HARVEST TECHNOLOGY PROGRAM

In order to improve post-production technology and nutritional quality, the Post-Harvest Technology programme set a number of objectives : assessment of post-production constraints in the rural areas, assessment of pre-storage losses, assessment of in-storage losses at the village level, generation and use of low-cost technology for processing and storage, evaluation of milling and sensory characteristics, promotion of improved processing and storage techniques in the region, promotion of rice by products utilization and training of technicians in post-harvest technology.

In 1986, as part of the strategy for assessing pre-storage losses, two members of staff (one entomologist from the WARDA Training Center and the maintenance technician attached to the post-harvest laboratory based at Fendall) attended courses on Storage of Tropical Crops at the Tropical Development and Research Institute (TDRI) at Slough, England, between August and December 1986. The four-month programs dealt, among other topics, with sampling and loss assessment methods.

The newly trained staff will assist the postharvest technologists in studies relating to food losses, storage technology and manpower training.

In the evaluation of the physical properties and milling qualities, a total of 58 rice samples was inspected and evaluated for milling performance at the WARDA Rice Post-harvest Technology Laboratory in Fendall, Liberia, in 1986. 50 of the samples were extra long grains while the remaining 8 were long grains. The samples came from the WARDA Irrigated Rice Research Station in Senegal, the WARDA Mangrove Rice Research station in Sierra Leone and the WARDA Germplasm Unit in Liberia. All samples were kept in an air-conditioned room (24 hours, 365/6 days a year except during periods of power interruption) for three months before tests were conducted. Table 1 shows the conditions of the grain immediately after opening each rice package.

Of the 50 extra long grain varieties tested, Suakoko 8 topped the line with a total recovery of 72.3% and head rice yield of 65.5%. ITA 254 and ITA 236 took the second and third positions with total recoveries of 75.6% and 72.5% and head rice yields of 63.1% and 62.6% respectively. The samples had low incidence of breakage, damaged kernels and chalky kernels. WAR 81-2-1-2, although it had 100% red kernels, gave a good recovery of 70.6% and an excellent output of head rice (65%). WAR 72-2-1-1, WAR 52-384-3-2-1 and Kuda Irang had very poor ratings while C-Bassin had to be discarded due to serious varietal mixing.

In the long grain category, WAR 27-28-1-3-1, Kuatik Kundur and I-KP gave the best yields (total milling recovery and head rice) while KSS and Tatsumi Mochi gave good milling outturn but lower head rice yields.

Table 1. Preliminary Evaluation Test Results (Summary)

	N#	1 Purity % Range	Median	2 IK %* Range	Median	3 MC% wb ** Range	Median
Fendall (Liberia)	16	80.3-95.6	89.4	0.3-3	1.4	11.6-14.8	12.3
Guakoko (Liberia)	16	87.5-98.3	93.3	0.6-19.3	4.1	11.9-13.8	12.8
Rokupr (Sierra Leone)	24.	94.2-99.6	98.4	0.0-1.8	0.0	11.4-13.7	12.5
St. Louis (Senegal)	16	92.9-97.4	95.4	0.9-10.5	4.8	12.4-14.0	13.2

N# = Number of Varieties Tested
IK* = Immature Kernels, %
MC%wb = Moisture Content % wet basis

A preliminary study on the prediction of total milling recovery of extra long grain indica rice without milling was undertaken. In the study, an attempt was made to predict total milling recoveries of extra long grain indica rices which are widely grown in West Africa. Multiple regression analysis on some physical properties of rough rice, moisture content and damaged kernel content as independent variables indicated strong relationships with total milling yield. Predicted values of milling yield from the regression equation obtained were between 3.5% and 4.7% of the measured values. Table 2 presents the results of the regression analysis.

Table 2

Variable	Coefficient	Std. Error	t	p %
Intercept	-2.012			
Varaible 1	1.308	0.474	2.76	1.24
Variable 2	-1.433	0.587	2.44	2.40
Variable 3	1.246	0.395	3.15	0.56
Variable 4	0.698	0.122	5.72	0.01
Variable 5	-0.191	0.053	3.56	0.25

R2 = 0.759

Number of observations = 24
Variable 1: Moisture content %, (MC)
Variable 2: Paddy shape, (L/W)
Variable 3: Rigidity Kg, (R)... breaking resistance
Variable 4: Brown rice yield, % (BR)
Variable 5: Damaged kernel content %, (DK)
Dependent variable: Total milling recovery, (Y

From the analysis, the milling recovery Y(%) is given by the equation.

$$Y = 2.01+1.31\ (MC)-1.43(L/W)+1.25(R)+0.7(BR)-0.19(DK)>$$

Further work with more rice varieties and more statistical analysis to expand on the number of observations and to minimize the effect of the unaccountable error in the regression equation respectively is required in this study.

It is envisaged that the development of a valid equation will reduce the tedious work associated with the evaluation of total milling recovery by about 50%.

Under the Unit's Technical Assistance Program, for the promotion of improved processing and storage techniques in the region, a rice processing expert and a maintenance technician inspected rice mills at three estates of the Liberia Produce Marketing Corporation (LPMC)

The rice mills, installed by WARDA engineers between the end of 1984 and early 1985, required thorough inspection after the first year of operation. Necessary recommendations have since been submitted to the LPMC management.

Following some controversy on the quality of parboiled rice imported into Liberia under the United States PL 480 program, samples were evaluated at the Post-harvest Technology Laboratory. The tests showed high incidence of fermented and damaged kernels which were suspected to have developed in storage prior to the parboiling process in the United States.

In the area of training, the Unit continued its efforts to promote the greater use of improved rice processing and storage techniques in the subregion by conducting the ninth Rice Post-harvest Technology Course between 12th May and 3rd July, 1986.

Twenty-three participants from nine member countries attended the course which was held at the WARDA Regional Training Centre in Fendall, Liberia. To date, a total of two hundred and fifteen persons in the post-production sector have been trained by WARDA since the inception of the course in 1977.

During the eight-week period, participants were acquainted with the various aspects of post-production rice technologies, operation and maintenance of grain handling and processing equipment as well as the socio-economic factors with direct and indirect effects on the production system. Lectures and laboratory sessions were delivered and conducted respectively by a combination of regular WARDA personnel (from headquarters and the research stations) and guest lecturers from the Tropical Development and Research Institute (England). Field trips were made to selected processing and storage installations within Liberia.

As far as collaboration with the other WARDA departments is concerned, the Unit's expert based in the Gambia continued to coordinate the Rokupr station's TAT activities in the Gambia in 1986. The expert also coordinated an in country training program on mangrove rice cultivation held in the Gambia in July 1986. Furthermore, in collaboration with the Communications Division and the Liberia Broadcasting System, the Postharvest Technology Unit, in June 1986, produced a 30-minute television program on training in post-harvest technology. The presentation included field and indoor training sessions as well as an interview on WARDA's mandate and program.

TRAINING DIVISION

The 1986 Training Program was one of challenges and opportunities created by events which required experimentation with new policies and models to maintain it at the level of previous years. Funding uncertainties and reductions, the occupation of newly completed additional dormitory facilities by Headquarters staff, and uncertainties about the program's future demanded innovative actions. Overall, the program was successful and the following activities were undertaken :

- the conduct of 8 short courses, some utilizing resources in cooperating institutions,

- implementation of new costing and budgeting policies, and

- significant policy, planning and program development activities in anticipation of new strategies and programs consistent with WARDA's new research directions.

During 1986, a number of short courses were organized at the Training Centre in Fendall, Liberia. These included the Farm Equipment Selection, Use and Management Course of 7 weeks' duration for 17 trainees, Bird Pest Survey and Control Methods Course (5 weeks) for 23 trainees, Rice Post-harvest Technology Course (8 weeks) for 23 trainees, Rice Production Specialists' Course (5 months) for 26 trainees, Audio-visual and Extension Communication Course (6 weeks) for 21 trainees, Rice Seed Multiplication Course (6 weeks) for 12 trainees, and Intensive Course on Rice Production and Extension (2 weeks) for 26 trainees.

In addition to organizing training courses at the Training Centre, the Division also carried out station-based ecology-related training in line with the decision to relate ecology-specific training with the appropriate research stations. With funding provided by the UNDP, the Rokupr Station conducted a one week intensive course in Mangrove Rice Production Research and Extension Methods for 26 extension staff in the Gambia.

The Division also undertook degree and degree-related training in collaboration with the University of Sierra Leone at Rokupr where dissertation support was provided to 4 candidates for the BSc. degree and to 6 candidates for the MSc. degree.

This type of training is seen as a crucial way of strenthening Member States research capabilities and for strengthening long-term relationships with WARDA.

Another major activity of the Division during 1986 was technical assistance to member states. In response to requests from Member States, the Division was invited by the PLAN INTERNATIONAL of Liberia to deliver lectures and conduct field demonstrations in a short intensive course for farmers of the Grand Cape Mount area. The Division also responded to an invitation from Guinea-Bissau and USAID/Bissau to conduct a feasibility study for a seminar on Rice Production and Water Management. Furthermore, at the invitation of the Agricultural and Industrial Training Bureau, the Division was represented at a one-day meeting convened on December 3, 1986 to discuss proficiency standards for graduates from the middle-level agricultural training institutions in Liberia.

OTHER COLLATERAL ACTIVITIES

In response to changing technology and suggestions from course participants and instructors, the curricula and programs of the Seed Multiplication and the Audiovisual and Extension Communication Courses were revised by the training staff and Headquarters-based scientists.

With the support of the British Technical Cooperation Fellowship program, two staff of the Division underwent a 4-month training in the storage of tropical agricultural products at TDRI in Slough, United Kindom. Storage is an important component of the Post-Harvest Training course and one of the staff was specially trained to teach the storage component of the course which had, up to 1986, been taught by two British experts through ODA assistance to WARDA.

A general brochure providing general information on WARDA's training program for Member States, donors and potential users of the Training Program was completed in 1986 and will be published early 1987.

As far as relations with member countries are concerned, WARDA not only collaborated with Member States' Ministries of Agriculture or Rural Development but also with the following institutions and organisations :

-FAO in hosting:

i) the Bird Pest Survey and Control Course at the Training Center (95 weeks)

ii) the Farm Equipment Selection, Use and Managemen Course (7 weeks), and

iii) planning a base study for a workshop on Extensi Campaign Planning to be held in 1987.

-IDRC in organising and conducting a course in Library Science and Management for a Sierra Leone National, Mr. Samuel B. Kargbo, with funds from IDRC.

-IDRI and ODA for providing two storage experts to teach the storage aspects of the Post-Harvest Technology Course.

As part of the effort to reorient the training programme, the Division undertook a study on the Preliminary Assessment of the Perceived Usefulness of WARDA's Short Courses.

From the responses of WARDA and Member States' scientists, the study established beyond doubt the usefulness and relevance of short courses and in particular the Rice Production, Research and Extension Courses.

A comprehensive study entitled "WARDA Training Policy" proposed policy changes especially with regard to the inclusion in budgets of donor-sponsored courses of all costs not otherwise supported, including reasonable charges for Center maintenance and improvement. Additionally, the paper proposed the establishment of a Special Training Fund to accumulate fees for training services provided by the Center for the Training Center and training program improvement. These policy changes were adopted by the Program Committee at the 1986 In-House Review, and were implemented during 1986.

Another paper on WARDA Training Strategy: "An Interim Statement of the Goals, Objectives and Approaches of WARDA's Training Program" prepared by the Division gives an overview of WARDA's training program and provides a comprehensive basis for reviewing the program against assessment of regional manpower and training needs.

In view of the cessation of USAID support for the Training Center and for the Rice Production Specialists' Course at the close of 1986 as well as the impending close of the UNDP project and uncertainties about donor funding for other courses in 1987, proposals were developed and sent to potential donors for funding.

Looking at the overall development of the Division in 1986, it can be said that in spite of the difficulties that faced the Division, it nevertheless made significant preparations for the long range planning and strategy exercise currently under way and that it will be in a position to participate fully in WARDA's transition process.

COMMUNICATIONS DIVISION

The Communications Division is a multipurpose unit that lends technical, linguistic and documentation support to WARDA scientists both at headquarters and in the Regional Research Stations. It is made up of four integral sub-units, namely : documentation and library, translation and interpretation, production, information and public relations.

The objectives of the Communications Division are the following :

- To ensure the production of WARDA's publications and their distribution to WARDA scientists and selected target audiences

- to ensure timely translation of all WARDA official correspondence, administrative and scientific documents as well as to provide interpretation and translation services at all WARDA meetings, seminars and training courses

- to disseminate all rice literature received from other institutions to WARDA scientists

- to undertake public relations activities intended to enhance public awareness of WARDA's activities and achievements through press coverage in the mass media.

Notwithstanding staff reduction in 1986 and budgetary limitations, the Communications Division nevertheless undertook a number of significant activities.

The Documentation and Library Unit collected, processed and disseminated rice information within and outside West Africa as part of its effort to set up an efficient library and documentation service. Special emphasis was placed on the supply of relevant information to WARDA scientists through the setting up of the Selective Dissemination of Information Service (SDI). As part of this service, the User's Interest Profile was revised to take into account the specific needs of each scientist. Furthermore, the Unit undertook the compilation of specialized bibliographies on rice and WARDA publications. It also collaborated with some international institutions such as FAO/AGRIS, CAB, Resources Development Centre, England (LRDC/TRADIS) and National Agricultural Library (NAL, U.S.A.) for the regular supply of current specialized bibliographies.

The Translation and Interpretation Unit continued in 1986 to carry out its traditional activities. In the main, the Unit translated all documents pertaining to the 1986 meetings of the Scientific and Technical Committee, the National Experts' Committee and the Governing Council. It also translated the WARDA Technical Newsletters and Occasional Papers, compiled new terminologies, updated and expanded the Rice Vocabulary, and provided interpretation services at all the WARDA meetings that were held during the year.

In addition to producing all the documents for WARDA meetings, the Production Unit published the WARDA Technical Newsletter, the Occasional Papers, the Rice Statistics Yearbook and the WARDA News Bulletin. For its part, the Public Relations Unit ensured the coverage of WARDA activities and achievements by newspapers, radio and television.

A P P E N D I C E S

APPENDIX 1: FINANCIAL STATEMENT

BUREAUX AU NIGERIA CAMEROUN SWAZILAND

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REPORT OF THE AUDITORS
TO THE COUNCIL OF MINISTERS OF
THE WEST AFRICA RICE DEVELOPMENT ASSOCIATION

We have examined the balance sheet of the West Africa Rice Development Association, (WARDA) as of 31 December 1986, and the related statements of income and expenditure, changes in fund balances, and source and application of funds for the year then ended. Our examinations were made in accordance with internationally accepted auditing standards and, accordingly, included such tests of the accounting records and such other auditing procedures as we considered necessary in the circumstances.

In our opinion, the financial statements referred to above present fairly the financial position of WARDA, as of December 31, 1986 and the results of its operations, changes in fund balances and changes in its financial position for the year then ended, in conformity with internationally accepted accounting principles.

Akintola Williams & Co.

CHARTERED ACCOUNTANTS

31 March 1987

WEST AFRICA RICE DEVELOPMENT ASSOCIATION
BALANCE SHEET AS AT 31ST DECEMBER 1986

	1986 $	1985 $
EMPLOYMENT OF FUNDS		
CURRENT ASSETS		
Stocks	25 028	17 963
Accounts Receivable:		
Donors	569 715	571 842
Staff	6 712	154 273
Others	92 842	146 515
Time Deposits	1 407 028	492 822
Bank and Cash Balances	1 034 804	1 580 098
	3 136 129	2 963 513
LESS CURRENT LIABILITIES:		
Accounts Payable	1 796 913	1 552 681
Contributions in Advance	34 218	223 882
Provisions and Accruals	427 140	693 646
Bank Overdraft	36 406	-
	2 294 677	2 470 209
NET CURRENT ASSETS	841 452	493 304
Donors' Counterpart of Deferred and current Liabilities	-	511 522
	841 452	1 004 826
LESS DEFERRED LIABILITIES	-	(176 150)
	841 452	828 676
FIXED ASSETS	6 103 494	6 029 664
	6 944 946	6 858 340
FUNDS EMPLOYED		
WARDA Special Fund	4 578 144	4 513 072
General Fund	(4 953 216)	(4 930 053)
Member States Fund	(375 072)	(416 981)
Trust Fund	1 216 524	1 245 657
NET FUND BALANCE	841 452	828 676
Capital Fund fully expended on fixed assets	6 103 494	6 029 664
	6 944 946	6 858 340

WEST AFRICA RICE DEVELOPMENT ASSOCIATION
STATEMENTS OF INCOME AND EXPENDITURE, AND CHANGES IN FUND BALANCES FOR THE YEAR ENDED 31ST DECEMBER, 1986

	WARDA SPECIAL FUND	GENERAL FUND	TRUST FUNDS	1986 TOTAL	1985 TOTAL
	$	$	$	$	$
INCOME					
Grants and Contributions	65 072	533 005	5 703 587	6 301 664	7 201 675
Miscellaneous Income	-	-	143 994	143 994	84 397
	65 072	533 005	5 847 581	6 445 658	7 286 072
EXPENDITURE					
Personnel	-	312 887	3 977 525	4 290 412	4 327 593
Travel	-	153 840	346 980	500 820	354 094
Services	-	-	347 214	347 214	394 414
Supplies	-	-	130 524	130 524	142 500
Others	-	256 193	854 620	1 110 813	690 926
Contingencies	-	-	53 687	53 687	-
Capital	-	-	78 813	78 813	331 780
Total Expenditure	-	722 920	5 789 363	6 512 283	6 241 307
Surplus/(Deficit) for the year	65 072	(189 915)	58 218	(66 625)	1 044 765
Fund Balances at 1st January 1986	4 513 072	(4 930 053)	1 245 657	828 676	(174 203)
Prior Year Adjustments, etc.	-	166 752	(87 351)	79 401	(41 886)
FUND BALANCES AT 31/12/86	4 578 144	(4 953 216)	1 216 524	841 452	828 676

WEST AFRICA RICE DEVELOPMENT ASSOCIATION
STATEMENT OF SOURCE AND APPLICATION OF FUNDS
FOR THE YEAR ENDED 31ST DECEMBER, 1986

	1986		1985	
	$	$	$	$
SOURCE OF FUNDS				
Increase/(Decrease) in Fund Balances :				
WARDA Special Fund		65 072		511 694
Capital Fund		73 830		323 587
Trust Fund		(29 133)		931 451
Deferred Liability		(176 150)		(397 964)
Fixed Assets Disposal		4 983		8 193
		(61 398)		1 376 961
APPLICATION OF FUNDS				
Decrease in Fund Balances:				
General Fund	(23 162)		(440 266)	
Counterpart of Deferred and Current Liabilities	-		(33 326)	
Purchase of Fixed Assets	(78 813)		(331 780)	
		(101 975)		(805 372)
Increase (Decrease) in Working Capital		(163 373)		571 589
Decrease in Accounts Receivable & Stocks	707 817		1 336 136	
Decrease in Accounts Payable	(211 938)		(611 665)	
		495 879		724 471
Net Increase in Liquid Funds		332 506		1 296 060
Cash, Bank & Deposit Balances at January 1, 1986		2 072 920		776 860
Cash, Bank and Deposit Balances at December 31, 1986		2 405 426		2 072 920

APPENDIX 2: PERSONNEL

PERSONNEL

Office of the Executive Secretary
Aliou M.B. Jagne, Acting Executive Secretary
S. Camara, MA, Internal Auditor

Administration and Finance
D. Amanu, FCCA, Financial Controller
G. Olaopa*, MS, Finance Officer
R. Becker*, Personnel Officer

Communications
L. Faye, Doctorat, Chief of Communications
T. Asongwed, M.A.; D.E.A. Translator/Interpreter
D. Gaye, BA, Translator
C. Soufflet, MA, Translator
A. Akotoye*, MS, Scientific Editor
A. Diallo, MS, Assistant Documentalist
M. Kwesi-Nartey, MA, Translator
S. Ronquillo, BS, Librarian

Scientific Staff of Research and Development Department
J.E. Johnston*, PhD, Director
D. Sanni, Eng. GR
V. Nyanteng, PhD, Senior Economist
S. Botchey, PhD, Senior Agronomist
G. Paku, PhD, Agro-statistician
L. Annat, Economist
A. Abifarin, PhD, Senior Breeder, IITA/WARDA Liaison Scientist
M. Samake, Economist

Post-harvest Technology Laboratory (Fendall, Liberia)
A. Adewusi, MS, Processing Engineer
A. Miyaishi, Processing Engineer

Seed and Germplasm Laboratory (Fendall, Liberia)
A. Larinde*, PhD, Seed Technologist
J. Olufowote, MS, Breeder

Regional Upland Rice Research Station (Bouake, Cote d'Ivoire)
K. Miezan, PhD, Geneticist Station Director
M. Choudhury, PhD, Senior Breeder
D. Das Gupta, PhD, Senior Agronomist
V. Awoderu, PhD, Senior Plant Pathologist
E. Akinsola, PhD, Senior Entomologist
B. Sarfo, MS, Agricultural Economist
R. Diallo, MS, Extension Agronomist
M. Diallo, Soil Scientist
J. Dallard, Breeder
G. Nyoka, PhD, Weed Scientist
M. Briat, Agronomist (Mechanization)
S. Diatta**, DEA, Agronomist

Regional Mangrove Swamp Rice Research Station (Rokupr, Sierra Leone)
M. Agyen-Sampong, PhD, Entomologist, Station Director
A. Sandhu, PhD, Extension Specialist
M. Jones+, PhD, Breeder
S. Fomba+, MS, Pathologist
C. Dixon+, MS, Pathologist
H. Bernard+, BS, Weed Scientist
W. Cole+, MS, Extension Agronomist
S. Fannah+, MS, Entomologist
J. Adam*, MS, Agricultural Economist
K. Prakah-Asante, PhD, Extension Economist

Regional Irrigated Rice Research Station
(St. Louis, Senegal)
A. Coly, PhD, Doctorat, Physiologist, Station Director
W. Godderis, Breeder
T. Diop, Associate Entomologist
N. Bangura, MS, Pathologist
H. Van Brandt, Agronomist
H. Diara, Biologist
I. Camara*, PhD, Soil Scientist
B. Gaye, Agricultural Economist
M. Diop, MS, Associate Weed Scientist
A. Kourouma, MS, Assistant Extension Agronomist
P. Sessou, Eng. TER, Rural Engineer
J. Moreira++, MS, Processing Engineer
F. Huibers, PhD, Water Management Specialist
J. Faucher**, Agronomist

Regional Deepwater/ Floating Rice Research Station+++
(Mopti, Mali)
S. Diatta, DEA, Station Director
D. Guindo+, Associate Entomologist
A. Coulibaly+, Associate Extension Agronomist
A. Traore+, Associate Agronomist
M. Goita+, PhD, Breeder
A. Diara+, PhD, Weed Scientist
A. Dembele+, MS, Agronomist
A. Toure+***, MS, Agronomist
J. Faucher, Agronomist

Training Department
D. Awute*, Eng. TA, Director
K. Conteh, MS, M.A., Head, Training Center
J. Nketsiah, Interpreter/ Translator
T. Seddoh, Interpreter/ Translator
T. Cole, MS, Trainer
A. Maiga, Doctorat, Trainer
I. Akintayo, PhD, Trainer

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* left during the year
** reassigned from Mopti Station during the year
*** left for study leave
\+ national program staff based at WARDA
++ based in The Gambia
+++ phased out during the year.

APPENDIX 3: PUBLICATIONS

1986 STAFF PUBLICATIONS

1. Akintayo, I. (1986). Effect of time and number of insecticidal applications on the control of rice stemborers in Fendall, Liberia. WARDA Tech. Newsl.6(1): 7-10

2. Akintayo, I. (1986). Outbreak of Eldana saccharina in rice ecosystem in Fendall area, Liberia. WARDA Technical Newsletter 6(1): 12

3. Bernard, H.M. and S. Soki-Harding (1986). Influence of flooding on the growth of Paspalum vaginatum (Sw). WARDA Technical Newsletter 6(1): 26-28

4. Bernard H.M. and S. Soki-Harding (1986). Competitive ability of two rice varieties on the growth of Paspalum vaginatum (Sw.). WARDA Technical Newsletter 6(1): 29-30

5. Das Gupta, D.K., and Awoderu, V.A. (1986). Preliminary studies on the effect of nitrogen levels on the performance of some rice varieties under lowland and iron toxic swamp conditions. WARDA Technical Newsletter 6(1): 1-3

6. Dixon, C.A. and H.F. Diara (1986). Azolla in Sierra Leone swamp rice farming. Azolla Newsletter 2(1): 3

7. Fomba, S.N. and S.I. Kamara (1986). Seedling resistance to the rice yellow mottle virus (RYMV) in some rice cultivars. WARDA Technical Newsletter 6(1): 20-21

8. Fomba, S.N. (1986). Grain yield losses caused by the neck blast, Pyricularia oryzae Cav. in unprotected tidal mangrove swamp rice in Sierra Leone. WARDA Technical Newsletter 6(1): 22-23

9. Fomba, S.N. (1986). Crop losses and other effects of attack caused by the rice yellow mottle virus on rice varieties, ROK 5 and Angkata at Rokupr, Sierra Leone. WARDA Technical Newsletter 6(1): 24-25

10. Jones, M.P. (1986). Genetic analysis of salt tolerance in mangrove swamp rice in Rice Genetics. Proceedings of the International Rice Genetics Symposium, IRRI, Los Banos, Philippines, May 27-31, 1985, pp. 411-422

11. Jones, M.P. (1986). Ratooning method to synchronize flowering in photosensitive and non photosensitive rice varieties. WARDA Technical Newsletter 6(1): 13-14

12. Jones, M.P. (1986). Comparative yield and other characteristics of the main and ratoon rice of tidal mangrove swamps of West Africa. WARDA Technical Newsletter 6(1): 18-19

13. Jones, M.P. (1986). Rohyb 15-WAR-3-3-B-2, a new rice variety developed for the salt limited, short-season mangrove swamps of West Africa. WARDA Technical Newsletter 6(1): 15-17

14. Miezan, K. and Ghesquiere, A. (1986). Genetic structure of African traditional rice cultivars. In Rice genetics: Proceedings of the International Rice Genetics Symposium, Los Banos, 27-31 May 1985. Los Banos, IRRI p. 91-107

15. Nyanteng, V.K. (1986). An overview of rice related policies and developments in Nigeria. WARDA Occasional Paper Ser.10. 59 p.

16. Nyanteng, V.K. (1986). Aspects of rice production, marketing and pricing in Burkina Faso. WARDA Occasional Paper Ser.9. 70 p.

17. Nyanteng, V.K. (1986). Riceland in West Africa: Distribution, growth and limiting factors. WARDA Occasional Paper Ser.7 21 p.

18. Nyanteng, V.K., Samake, M. and Longabough, S. (1986). Socio-economic study of rice farming in Mali: the household, farms, labour characteristics and constraints. WARDA Occasional Paper Ser.8. 51 p.

19. Olufowote, J.O. and Akintayo, I. (1986). Reactions of some elite cultivars to stemborers infestation under irrigated conditions at Fendall, Liberia. WARDA Technical Newsletter 6(1): 10-11.

1986 CONFERENCE AND SEMINAR PRESENTATIONS

1. Agyen-Sampong, M., Prakah-Asante, K. and Fomba S.N. (1986). Rice improvement in the mangrove swamps of West Africa. Paper presented at the Third International Symposium on Acid Sulphate Soils, Dakar, Senegal, January 6-11, 1986.

2. Agyen-Sampong, M. and Fannah, S.J. (1986). Phenology of the white rice borer Maliarpha separatella Rag. (Lepidoptera: Pyralidae) in the mangrove swamp rice ecology of orthwest Sierra eone. Paper presented at the International Conference on Tropical Entomology, Nairobi, Kenya, August 31 to September 5, 1986.

3. Agyen-Sampong, M., Jones, M.P. and Fomba, S.N. (1986). The status of mangrove swamp rice research and development in Sierra Leone. Paper presented at the 15th Annual Conference of the Sierra eone Agricultural Society, Makeni, Sierra Leone, October 1-5, 1986.

4. Dixon, C.A. (1986). Fertilizer response of rice in some acid sulphate soils in West Africa. Paper presentd at the Third International Symposium on Acid Sulphate Soils, Dakar, Senegal, January 6-11, 1986.

5. Jones, M.P. (1986). Rice breeding for adverse soils in the mangrove swamps of West Africa. Paper presented at the Third International Symposium on Acid Sulphate Soils, Dakar, Senegal, January 6-11, 1986.

APPENDIX 4: WARDA ADDRESSES

WARDA ADDRESSES

Headquarters

WARDA
LBDI Complex
Tubman Boulevard
P.O. Box 1019
Monrovia, Liberia
Telephone : 261-847 or 261-683
Telex : 0997 - 44333 WARDA LI

Regional Research Stations

WARDA Regional Upland Rice Research Station
01 B.P. 2551 Bouaké 01
Côte d'Ivoire
Telephone 63-10-52 or 63-10-53
Telex 69138 ADRAO BOUAKE

WARDA Regional Mangrove Swamp Rice
Research Station/Rokupr
P.M.B. 736
Freetown, Sierra Leone
Telex 3418 PEMSU SL

WARDA Regional Irrigated Rice Research Station
B.P. 96
Saint-Louis, Sénégal
Telephone 63-11-93
Telex 7772 ADRAO SG

WARDA Regional Training Centre/Fendall
P.O. Box 1019
Monrovia, Liberia