Rice improvement in the mangrove swamps of West Africa

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1 Summary

In West Africa more than 200,000 ha of mangrove swamp, with predominantly acid sulphate soils are being cropped for rice. Rainfall regimes, tidal movement, fresh water supply from river and rainfall, and environmental stress of the mangrove swamp differ from area to area and the need for varieties and farming practices differ accordingly. Constraints of mangrove swamp rice farmers have been identified and research strategies to solve the problems are developed by West Africa Rice Development Association at Rokupr. Results of the research work on Varietal Improvement, Soil and Crop Management, Pest Management, Technology Assessment and Transfer Training are discussed.

Résumé

Le régime de précipitations, le mouvement tidal, l'apport de l'eau douce des rivières et précipitations, ainsi que les stress de l'environnement des mangroves, différent d'une place à l'autre. C'est pour cela que les pratiques d'aménagements doivent être différentes, comme différentes doivent être aussi, les variétés de riz cultivées.

L'association pour le Développement de la Riziculture en Afrique Occidentale de Rokpur, a étudié les contraintes des 'rizières profondes' et a élaborée des stratégies de recherches pour l'amélioration.

L'article discute les résultats concernant l'aménagement du sol et des cultures, la tolérance des variétés, la lutte contre les maladies, la vulgarisation des connaissances et technologies.

Un monitoring du pH et de la teneur en sels a été réalisé durant plusieurs années, en vue de connaître l'acidité et la salinité des sols, et d'expériences à divers doses de fertilisants (NPK) ont été conduites, afin de pouvoir determiner les meilleurs reponses de plantes.

Au Sierra Leone, l'application de l'azote par injection d'une solution aqueuse d'urée à 20 cm de profondeur a donné d'excelents résultats. De même, l'application de 20 kg P/ha sous forme de superphosphate a augmenté l'efficacité de l'azote et a apporté d'importants surplus de récolte. Par contre, en Gambie, seul le phosphore a été l'élément nutritif défficitaire et l'application de l'azote n'a pas apporté d'augmentation de récolte.

La potassium, seul ou en différentes combinaisons, n'a pas apporté non plus d'augmentation de récolte.

En 8 années, environs 3000 variétés/lignées de riz ont été introduites et triées pour des conditions de mangroves à influence tidale et non-tidale.

Les régions tidales de Guinée, semblent très favorables à la cultivation du riz à courte période végétative. Environ 1000 variétés locales et séléctionées ont été identifiées comme résistantes aux Diopsis thoracica et Maliarpha separatella, et quelques centaines, comme multirésistantes aux maladies, insectes et crabes.

La destruction des mauvaises herbes par des moyens mécaniques et chimiques c'est avérée efficace tant au Sierra Leone, que dans les autres pays de l'Afrique Occidentale.

La vulgarisation des résultats et la culture de certaines variétés résistantes, comme l'utilisation massive de certaines techniques est de plus en plus large.

ROK 5 est une variété utilisée par 90% des paysans de Gambie et Guinée-Bissau et ROK 10 commence aussi d'être acceptée à large échelle.

2 Introduction

2.1 The mangrove rice situation in West Africa

Rice is grown on about 214,000 ha of cleared mangrove swamps in Guinea-Bissau, The Gambia, Guinea, Nigeria, Senegal and Sierra Leone (Figure 1) and large areas are being brought under cultivation. A further 150,000 ha remain uncleared in Sierra Leone up to Senegal, and about 800,000 ha in Nigeria (WARDA 1983b). These swamps are mainly acid-sulphate soils.

The swamps have been continuously cropped for over 100 years with about 100,000 farm families involved in the West Africa sub-region. Most farms are manually operated and cultivated with low yielding varieties without fertilizer or pest control. The farmers are also constrained by limited labour, transportation, extension and education and by lack of credit and input availability.

However, the mangrove swamp environment is still more fertile than the other traditional rice areas. For example, mangrove swamp rice comprises about 7 per cent of the area under rice in West Africa but it accounts for about 12 per cent of production. Yields of husk rice average 2.0 metric tons per ha. but there are indications that the use of practical modern techniques can double production per unit area (WARDA 1984).

The relative importance of mangrove swamp rice cultivation varies from country to country as indicated in Table 1.

Table 1 Relative importance of mangrove swamp rice cultivation in West-Africa

Country	Area under mangrove swamp rice (ha)	% National	
		Rice area	Rice production
Guinea-Bissau	90,000	80	80
The Gambia	10,000	52	54
Guinea	64,000	12	18
Senegal	10,000	20	16
Sierra Leone	35,000	6	12
Nigeria	5,000	–	–

Source: WARDA 1983b

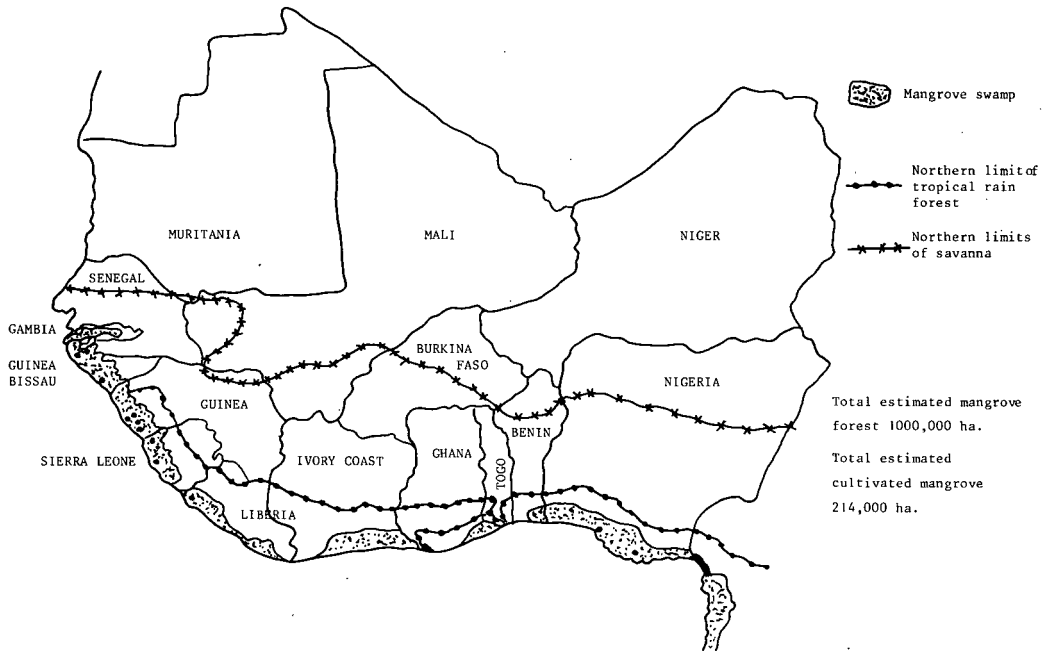

Figure 1 Distribution of mangrove swamps in West Africa

The mangrove swamp rice area in West-Africa covers a wide range of climatic conditions from dry tropical climate with about 1,000 mm of rain at Casamance (Southern Senegal) to humid tropical climate with about 4,000 mm of rain in Sierra Leone, Southern Guinea and southern Nigeria. However, successful cultivation of rice on any one area depends on the length of 'the salt free period' which is the result of an interplay of the volume of fresh water available and salt water intrusion from the sea. Between the tidal swamps and the uplands lie so called 'associated mangrove swamps' which are characterized by excessive grass and sedge weeds, with fewer broad leaved ones.

2.2 Strategy for Rice Improvement

The combined factors of variable climatic conditions and the different durations of the salt free period provide a strong challenge to the West Africa Rice Development Association (WARDA) Regional Mangrove Swamp Rice Research Station at Rokupr. The methodologies developed for rice improvement are based on a multidisciplinary team strategy. Generally, the station has five broad responsibilities, namely, Varietal Improvement, Soil and Crop Management, Pest Management, Technology Assessment and Transfer, and Training. Concerted activity by the multi- disciplinary team is obtained by interactions as well as delivery and feedback relationships among the various sections (Figure 2).

The development of new technologies starts with the testing of techniques on farm scale and evaluating promising techniques together with the farmers in our Technology

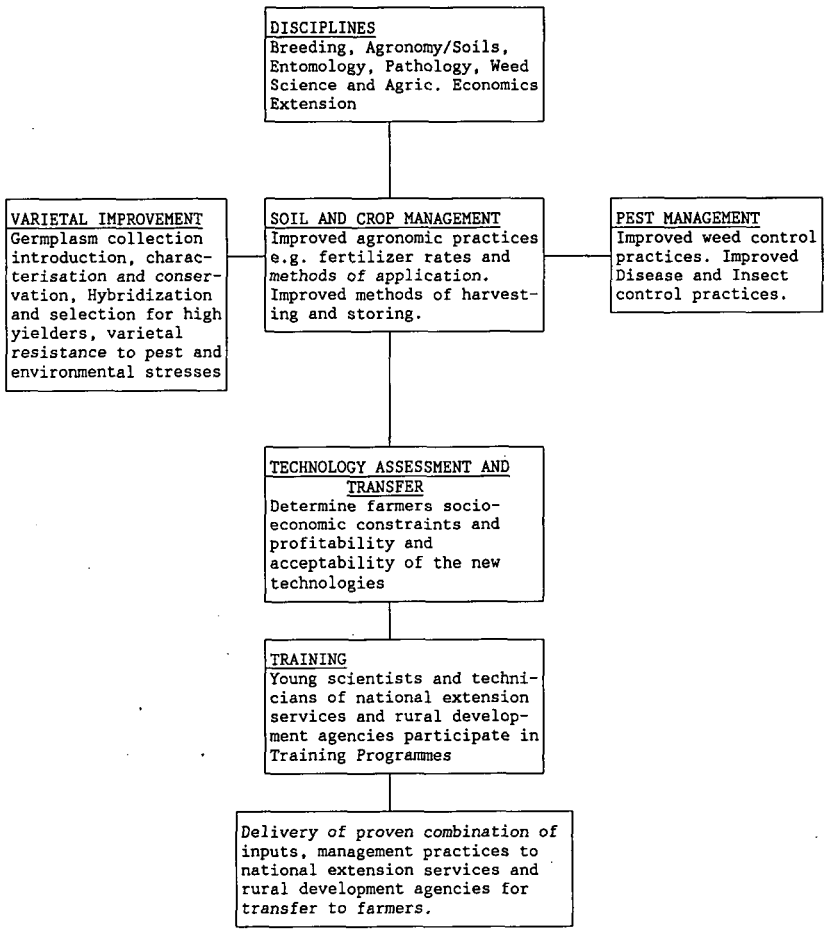

Figure 2 Strategy of inter-disciplinary approach at the WARDA regional mangrove swamp rice research station, Rokupr, Sierra Leone to solving rice production problems

Assessment and Transfer section. Successful techniques are then passed on directly to farmers by the scientists involved and to established extension authorities and other development agencies or projects in Guinea, Guinea-Bissau, The Gambia, Senegal and Sierra Leone. The salient findings of the Station to date are summarized hereafter on a section by section basis for ease of presentation.

3 Varietal improvement

3.1 Introduction of varieties

Between 1976 and 1984 2840 varieties/lines have been introduced and screened for adaptation to the mangrove swamp environment. Their origins and the number selected for further testing and nomination into mangrove swamp Advance Varietal

Trials (AVT) are shown in Table 2. The AVT varieties have proved suitable for both the empoldered mangrove swamps in the north of the region and for the open tidal swamps of Sierra Leone and Guinea (Table 3). In view of recent drought conditions in the Sahel selection of short duration varieties is of increasing importance (WARDA 1982-1984).

Table 2 Introduced varieties/lines screened at Rokupr for adaptation to mangrove swamp conditions

Year	Number of introduc-tions	Origin of Materials	Number of Varieties /lines selected	Number nominated for advanced variety trials
1976	330	IITA, Nigeria	54	2
1977	343	WARDA, Liberia	49	1
1978	437	IRTP (IRRI) Germplasm Bank, Philippines	62	10
1979	57	IRRI Germplasm Bank, Philippines	18	5
1980	71	IRTP (IRRI), Philippines	9	4
1981	536	IRTP (IRRI), Philippines	127	–
1982	132	IRTP (IRRI), Philippines	22	–
1983	407	IRTP (IRRI), Philippines	89	–
1984	529	IRTP (IRRI), Philippines	103	–

Table 3 Varieties nominated by WARDA Regional Mangrove Swamp Rice Research Station, Rokupr, Sierra Leone for mangrove swamp Region-wide variety trials

Year	Variety	Year of introduc-tion	Height (cm)	Duration (days)	Average yield (t/ha)
1980	Bali Grodak	1976	135	162	3.1
	Djabon	1976	139	162	3.1
1981	Kuatik Jambi	1978	137	169	3.8
	Kuatik Kundur	1978	142	175	3.7
	Padi Mentul	1978	151	173	3.6
	Tat No	1978	154	170	3.4
	Sentral Merah	1978	147	159	3.3
	Nang Ra	1978	145	170	3.2
	Kuatik Putih Tinggi	1978	151	174	3.2
1982	IR3259-P5-160-1	1977	94	143	4.6
	IR4707-140-1-3	1979	92	135	3.7
	IR2797-125-3-2-2-2	1979	94	134	3.5
	IR4712-113-3-1-2	1979	102	131	3.3
1983	IR5677-17-3-1-1	1979	117	150	4.3
	Rohyb6-WAR-6-2-B-2	**	153	170	3.2
	Haji Haroun	1978	133	160	2.9
	Bay Danh	1978	156	171	2.6
	Raden Mas	1978	166	175	2.4
	Rohyb1-WAR-5-2-B-2	**	156	168	2.3
1984	IR10781-143-2-3	1980	108	134	4.9
	IR13426-92-1	1980	99	130	4.6
	IR14753-120-3	1980	98	135	3.7
	Rohyb15-WAR-3-3-B-2	**	125	157	3.9
	IR11248-148-3-2-3-2	1979	88	124	3.5
	IR13240-39-3	1980	87	121	3.2

** Bred at Rokupr

3.2 Breeding

In the past 6 years a total of 146 crosses have been successfully made and several promising lines have been tested on farmers rice fields and are now being recommended for release in Sierra Leone. Notable among these are Rohyb15 and WAR74 for tidal swamps with a short salt free season (Jones 1985). Several promising lines for long season swamps are also in the offering (WARDA 1984).

3.3 Varietal resistance to Pests

About 1000 local and introduced rice varieties have been evaluated for resistance to 'dead heart' caused by Diopsis thoracica, and 'stem infestation' caused by Maliarpha separatella under natural level of infestation in collaborative work between the entomologist and breeders. In general the introduced varieties do not perform well in mangrove swamps and are more susceptible to 'dead heart' than local varieties. However, stem infestation is higher in local varieties than in exotic rices (WARDA 1983b).

Mass screening of the Station's genetic stock for resistance to crab damage was initiated in 1981 using a method developed at Rokupr (Agyen-Sampong, in press). The results indicate that all seedlings with long leaves and thick bases are generally more tolerant to crab damage, with the resistance mechanism being morphological in nature.

3.4 Varietal resistance to diseases

Several hundreds of varieties/lines have been screened against rice diseases in multilocational testing since 1982 in the Scarcies and Moyamba regions of Sierra Leone. Several test entries showed multiple resistance to seedling blast (Pyricularia oryzae) in the nursery, brown spot (Cochliobolus miyabeanus = Helminthosporium oryzae), leaf scald (Rhynchosporium oryzae) and leaf smut (Entyphoma oryzae) and also the white borer, M. separatella viz. WAR24-10-2-2, WAR25-14-1-2, WAR25-18-5-1, WAR27-34-4-1, WAR35-19-1-2, and WAR74-23-2-2-B-2 (Fannah et al. 1985). Also several varieties or lines were rated resistant to rice yellow mottle virus (RYMV) in a seedling screening test at Rokupr. These include TOX 502-SLR, LAC23, ITA116, IRAT170, and ROK 16 (WARDA 1984).

4 Soil and crop management

4.1 Salinity and pH levels

The salt content and pH along the Great Scarcies river have been routinely monitored for several years. The data obtained have facilitated the establishment of safe levels of salinity and acidity conditions for rice growth in different areas of the Scarcies region mangrove swamps.

4.2 Nitrogen fertilization

Nitrogen is limiting in the mangrove swamps of Sierra Leone (WARDA 1976-84). The Station has therefore developed a point application technique of injecting an aqueous solution of urea at about 20 cm depth. The device comprises a Knapsack sprayer with the lance converted into a needle for placement of fertilizer solution at the required depth (WARDA 1976; Jones this symposium).

4.3 Response to phosphorus and potassium

Results of long term trials evaluating nitrogen (N), phosphorus (P) and potassium (K) alone, and in various combinations indicated no response to potassium, and only occasional response to phosphorus. However, Will and Janakiram (1974) had earlier reported positive results with phosphorus at Rokupr. It appears that application of 20 kg per ha as single superphosphate produced a response to nitrogen and increased grain yield significantly in tidal swamp with limited flooding but increasing the level to 40 kg P per ha does not cause a significant increase in yield (WARDA 1983). In the Gambia phosphorus was observed to be the limiting nutrient; here no consistent response to nitrogen was observed.

4.4 Mechanical cultivation

A 8 hp single axed power tiller has been successfully utilized for cultivating the swamps in Sierra Leone and Guinea (WARDA 1983b). In on-farm trials comparing mechanical cultivation to the farmers traditional method of land cultivation using a long wooden handled hoe or 'mattock', mechanical cultivation gave superior grain yields (WARDA 1982-84). This result was probably due to greater mineralization of organic matter and better suppression of weeds with mechanical cultivation. However, ploughing below 15 cm in some areas can expose potentially acid sulphate sub-soil.

5 Pest management

The ultimate aim of mangrove swamp rice pest management is to devise a practical integrated control strategy based on sound knowledge of the ecology of key pests and the crop losses caused by them and coupled with sound crop husbandry and the use of resistant cultivars.

5.1 Weed surveys

Paspalum vaginatum, or 'Kire Kire', a salt tolerant graminaceous weed is the dominant weed in tidal mangrove swamps of Sierra Leone, The Gambia, Guinea and Guinea Bissau. Alternanthera sessilis is also found in saline swamps of these countries though it is relatively less in Sierra Leone (Bernard 1978; WARDA 1977-84). In the

'associated swamps' in areas that are transitional to the upland, a broad spectrum of weeds including grasses, sedges, and some broad leaved weeds occur.

5.2 Weed control

In the 'associated swamps' farmers usually hand weed once but this is hardly enough to control the serious weed infestation problem. However, in the normal tidal mangrove swamps single hand weeding is enough and in some cases no weeding is necessary.

Land preparation (ploughing and puddling) by the power tiller before transplanting has been found to suppress weeds most effectively and to yield more grain in Sierra Leone, and Guinea (WARDA 1978-84). This method can be applied in other West-African mangrove areas with similar weed flora (Fomba et al. 1984).

Trials with the herbicide Stam F34T (Propanil + Fenoprop) indicate that this chemical can control a broad spectrum of weeds in the 'associated swamps' especially where the fields are mechanically cultivated.

5.3 Disease surveys and monitoring

Disease surveys conducted in mangrove swamps of Sierra Leone, Guinea, Guinea-Bissau, The Gambia and Nigeria, and field observations at Djibélor in the lower Casamance region of Senegal have revealed the incidence of a broad spectrum of rice disease (WARDA 1977-84). The major rice diseases recorded were blast (Pyricularia oryzae) on upland nursery rice and in some fields, brown spot (Helminthosporium oryzae), leaf scald (Rhynchosporium oryzae), leaf smut (Entyloma oryzae) and 'dirty panicle' or grain discoloration syndrome; rice yellow mottle virus (RYMV), a potential problem, was also recorded in Sierra Leone, Guinea and Guinea-Bissau (WARDA 1977-84; Raymundo 1980).

However, the intensity varied from place to place and from country to country. Sierra leone, southern Guinea and Nigeria are ecologically similar, and so are the disease problem.

Guinea-Bissau, parts of northern Guinea and Casamance are also similar with respect to disease incidence and severity; The Gambia mangrove swamps were relatively less affected than the others in the sub-region.

5.4 Assessment of crop losses due to diseases

Grain yield losses caused by foliar rice brown spot disease (H. oryzae), in mangrove swamps of Sierra Leone were estimated at 7.3 to 19.8 per cent on a number of varieties of both improved and traditional cultivars (WARDA 1984). For neck blast (Pyricularia oryzae) losses from 16.4 to 30.7 per cent were observed. Potential grain yield losses due to rice yellow mottle virus range from 19.6 to 95.8 per cent with 4 week old seedlings incurring the greatest damage when rice plants were artificially infested with the virus in a screenhouse study; adult plants were generally least affected (WARDA 1984).

5.5 Disease control

Soil amendment with straw in 'associated mangrove swamps' and balanced fertilizer application reduced brown spot infection (WARDA 1984). In a tidal mangrove swamp at Rokupr early transplanting in July and August resulted in less brown spot infection and larger grain yields even without nitrogen than with crops sown in September to October (WARDA 1982-84).

Several fungicides such as Kocide, Beam (Tricyclazole), Protector (S-Haris), Prochloraz, Cuprosam 311 super D, and a mixture of Benlate (Benomyl) and Kocide reduced brown spot, leaf scald and leaf smut incidence on rice in an 'associated mangrove swamp' at Rokupr, and again adequately controlled seedling blast (P. oryzae) in rice and dryland (WARDA 1983-84).

5.6 Insect survey and collections

A wide range of rice pests has been recorded in mangrove swamps of West Africa with varying intensity of infestation and damage from place to place depending on the climate, time of planting, varieties and soil fertility. The white borer, Maliarpha separatella had been found to be the most dominant stemborer in mangrove swamps of Nigeria, Sierra Leone, Guinea-Bissau, and The Gambia (WARDA 1976-84). The striped rice borer, Chilo spp., the stalked-eye borer, Diopsis thoracica, and rice bugs are also quite common in these swamps.

At Caboxanque in Guinea-Bissau there was usually high incidence of gall midge, Orseolia oryzivora. Chilo zacconius was found to be a common stemborer at both Caboxanque and Djibélor in the lower Casamance region of Senegal.

5.7 Assessment of crop loss due to insects

Preliminary on-farm trials in mangrove swamps of northwest Sierra Leone indicate a range 35-1000 kg/ha grain yield reduction due to infestation by M. separatella (WARDA 1977-83).

Per cent grain yield loss due to insect pest infestation in some promising varieties ranged from 4.0 to 20.2 (WARDA 1978-83).

Rice bugs (Aspavia armigera and Stenocoris southwoodi) caused considerable grain yield losses and are associated with the 'dirty panicle' or discoloured grains syndrome (Agyen-Sampong and Fannah 1980). It was established in a screenhouse study that the percentage of grain damage increased as the rice bug density increased.

5.8 Pest control

Cultural control methods restrict or prevent pest damage by reducing pest population, and are generally economical and widely applicable. Destruction of rice stubbles after harvest, timely planting to avoid peak periods of adult emergence, and close plant

spacing alone, and in combination lead to lowering Maliarpha infestation in mangrove swamp rice (WARDA 1978-81).

Twenty-two species of egg and larval parasitoids of eight species of rice pests have been recorded in biological control studies in mangrove swamps of northwest Sierra Leone. Parasitism of about 15.0 per cent was recorded at 6 weeks after seedling transplanting and up to 90.0 per cent at the latter part of the season.

5.9 The ecology of crab pests in mangrove swamp rice

Of the nine species of crabs recorded in mangrove swamp rice fields, Sesarma huzardi, S. Alberti, and Sarmatum curvatum cause extensive destruction of newly transplanted rice seedlings by their feeding habits (Jordan 1958; Agyen-Sampong, in press).

Sesarma huzardi is the most voracious and common species in tidal mangrove swamps along the Great Scarcies river in Sierra Leone. It is transversely distributed across and along rivers and creeks up to the tidal limit (WARDA 1977-84).

5.10 Crop losses due to crabs

Grain yield losses on farmers' rice fields have been estimated at 19.0 to 34.0 kg/ha for every 1.0 per cent crab damage (WARDA 1978-83). Crab damage can be lessened by growing fewer older, vigorous, fertilizer treated seedlings and/or seedlings soaked in 1.0 per cent a.i. concentration of Furadan for 24 hours (WARDA 1978-83). Use of resistant cultivars further reduced crab damage in mangrove swamp rice (WARDA 1983).

6 Technology assessment and transfer

The Technology Assessment and Transfer (TAT) aspect of the Station's programme ensure that technology developed at the Station are passed by studies which help the scientist to understand farming systems more adequately and determine the constraints to which solutions can be addressed.

The technologies developed by the multidisciplinary team of scientists are then organized into packages and placed in adaptive trials for testing under farmers' socio-economic situation for suitability, acceptability and profitability (Prakah-Asante et al. 1984).

6.1 Farming systems

In the Scarcies area of Sierra Leone 90% of the population is agrarian. For the Conakry and Coyah regions of Guinea 22% is non-farming, main non-farm activities being trading, fire-wood industry and boat-making. Roughly 80% of the farming population in the Scarcies area and about 75% in the Conakry and Coyah regions of Guinea,

cultivate rice in the mangrove swamps but combine this with upland crops such as cassave, potatoes, and upland rice.

The average rice holding of the Scarcies farmer is about 1 ha, for which he nurses roughly 100 kg of seeds. Average yields in the areas with long fresh water season of the Scarcies region was recorded at 2.0 tons per ha against 2.6 tons per ha in the short season areas near the sea. In the Conakry regions of Guinea rice holdings are smaller (less than 1 ha) and yields are generally below 2 tons per ha.

6.2 Farm labour

In the Scarcies about 85% of farm labour is provided by the household which comprises about 3 male adults and youth, 4 female adults and youth, 2 children, 1 aged and 1 permanent labour. The remaining 15% is obtained from non-household sources. The household spends about 350 man-days per ha per year. Transplanting (including uprooting of seedlings), harvesting, and ploughing are the most labour intensive operations demanding about 220 man-days per ha.

6.3 Constraints to rice production

The main general constraint to rice production in mangrove swamps, is early recurrence of mineral stress, especially salinity due to vinicitudes of rain and hydrological regimes, or deficiencies in water control systems. Inadequate availability of fresh water may lead to complete crop failure and even abandonment of fields.

Biological constraints such as weeds, disease and pests could lead to serious losses in production, as discussed earlier. Low yielding varieties and the traditional practices of farming which generally exclude soil amendments, effective control of weeds, diseases and pests, also limit production. Most of the farmers in the Scarcies area are also faced with capital and labour scarcity which generally prevent input acquisition and farm expansion.

6.4 New technologies

The results of adaptive trials under farmers' management indicate that a technology package consisting of mechanical cultivation with single axled power tiller, modern varieties (ROK10 for areas with a long salt season, and ROK5 in short season areas), and injection of urea fertilization can increase yields by almost 100%. Morever, the package can reduce labour use by approximately 13-23 man-day per ha. Though there is evidence of large scale adoption of the modern varieties, adoption of the complete package requires support by a programme for credits, supply of farm inputs and marketing. Net revenue analysis of the package indicates that it is profitable at existing price levels and within a reasonable range of input and output prices.

6.5 Cooperation with other agencies

WARDA is developing and diffusing new technologies in active cooperation with local, national, regional and international authorities, institutions and projects. With such agencies joint protocols for field trials are agreed upon that secure the necessary feedback from the farmers' experiences all over the region.

In Sierra Leone, for example, a joint programme of field trials and demonstrations is taken up with the North West Integrated Agricultural Development Project (NWIADP), the Adaptive Crop Research and Extension (ACRE) Project, and the Moyamba Integrated Development Project (MIRDP). The Rokupr team has similar relationship with Opération Nationale pour la Développement de la Riziculture (ONADER) in Guinea, Freedom From Hunger Campaign (FFHC) in The Gambia; the Dutch, Swedish, and USAID Projects in Guinea-Bissau; National Crop Research Institute (NCRI), and the University of Port Harcourt in Nigeria and the Ministry of Agriculture in each of the specified countries. Among the programmes of field trials and experimentation, the Rokupr Station offers training for supervisory and field staff for most of the countries indicated.

7 Conclusions

Research activities undertaken by the West Africa Rice Development Association (WARDA) Regional Mangrove Swamp Rice Research Station at Rokupr, Sierra Leone since 1976 indicate that it is feasible to double the present average yields of rice of 2.0 tons per ha in most mangrove swamps of the humid tropical part of West Africa by use of appropriate technology packages developed at Rokupr. The implementation of the new technologies requires continued cooperation between research, development and extension agencies in the region and also increase of training facilities and availability of credit and technical assistance to farmers.

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