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LOWLAND CROPPING SYSTEMS IN THE LOWER CASAMANCE OF SENEGAL: RESULTS OF FOUR YEARS OF AGRONOMIC RESEARCH (1982-1985)

by
Joshua Posner, Mulumba Kamuanga, and Mamadou Lo

Reprint No. 30 1991

itut Sénégalais
cherches Agricoles
B.P. 3120
epublique du Sénégal

Department of Agricultural Economics
Michigan State University
East Lansing, Michigan 48824-1039

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SPECIAL NOTE FOR

ISRA-MSU REPRINTS

In 1982 the faculty and staff of the Department of Agricultural Economics at Michigan State University (MSU) began the first phase of a planned 10- to 15-year project to collaborate with the Senegal Agricultural Research Institute (ISRA, Institut Sénégalais de Recherches Agricoles) in the reorganization and reorientation of its research programs. The Senegal Agricultural Research and Planning Project (Contract No. 685-0223-C-00-1064-00), has been financed by the U.S. Agency for International Development, Dakar, Senegal.*

As part of this project MSU managed the Master's degree programs for 21 ISRA scientists at 10 U.S. universities in 10 different fields, including agricultural economics, agricultural engineering, soil science, animal science, rural sociology, biometrics and computer science. Ten MSU researchers, on long-term assignment with ISRA's Department of Production Systems Research (PSR, Département de Recherches sur les Systèmes de Production et le Transfert de Technologies en Milieu Rural) or with the Macro-Economic Analysis Bureau (BAME, Bureau d'Analyses Macro-Economiques) have undertaken research in collaboration with ISRA scientists on the distribution of agricultural inputs, cereals marketing, food security, and farm-level production strategies. MSU faculty have also advised junior ISRA scientists on research in the areas of animal traction, livestock systems and farmer groups.

Additional MSU faculty members from the Departments of Agricultural Economics, Sociology, Animal Science and the College of Veterinary Medicine have served as short-term consultants and scientific advisors to several ISRA research programs.

The project has organized several short-term, in-country training programs in farming systems research, farm-level agronomic research, and field-level livestock research. Special training and assistance has also been provided to expand the use of micro-computers in agricultural research, to improve English language skills, and to establish a documentation and publications program for PSR Department and BAME researchers.

Research conducted under this collaborative project was originally published only in French. Consequently, the distribution of results has been limited principally to West Africa.

In order to make relevant information available to a broader international audience, MSU and ISRA agreed in 1986 to publish selected reports as joint ISRA-MSU International Development Paper Reprints. These reports provide data and insights on critical issues in agricultural development which are common throughout Africa and the Third World. Most of the reprints in this series have been professionally edited for clarity; maps, figures and tables have been redrawn according to a standard format. Most reprints are available in both French and English. A list of available reprints is provided at the end of this report. Readers interested in topics covered in the reports are encouraged to submit comments directly to the respective authors, or to Dr. Eric W. Crawford, Director, Senegal Agricultural Research II Project, Department of Agricultural Economics, Michigan State University, East Lansing, MI 48824-1039.

Jean-Pierre Ndiaye
Director
Agrarian Systems and
Agicultural Economics
Research Department
Senegal Agricultural Research
Institute

Eric W. Crawford
Director
Senegal Agricultural Research II
Project
Department of Agricultural
Economics
Michigan State University

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*In December 1987 MSU, ISRA and USAID/Dakar negotiated a 2 1/2 year contract (Contract No. 685-0957-C-00-8004-00) to extend MSU's program of research support and training in the social sciences, agronomy, forestry and research planning.

LOWLAND CROPPING SYSTEMS IN THE LOWER CASAMANCE OF SENEGAL: RESULTS OF FOUR YEARS OF AGRONOMIC RESEARCH (1982-85)

by

Joshua Posner, Mulumba Kamuanga and Mamadou Lô

1991

This reprint is based on annual reports of the ISRA Production Systems Research Team located at Djibélor. Team members included S. Sall, F. Diamé, M. Diouf, A. Fall, M. Kamuanga, M. Lô, J. Posner and L. Sonko.

The reprint is published by the Department of Agricultural Economics, Michigan State University, under the Senegal Agricultural Research II Project Contract 685-0957-C-00-8004-00 at Michigan State University funded by the U. S. Agency for International Development, Dakar, Senegal.

ISSN 0731-3438

Published by the Department of Agricultural Economics, Michigan State University, East Lansing, Michigan 48824-1039 U.S.A.

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FOREWORD

The research reported in this document is based on the joint efforts of the members of the Farming Systems and Technology Transfer team at the Senegalese Institute for Agricultural Research (ISRA) station in Southern Senegal during a four-year period (1982-1985). In addition to the authors, five other researchers were members of the multidisciplinary Farming Systems team at the Djibélor station: S. Sall, F. Diame, M. Diouf, A. Fall, and L. Sonko.

September 1991

LOWLAND CROPPING SYSTEMS IN THE LOWER CASAMANCE OF SENEGAL: RESULTS OF FOUR YEARS OF AGRONOMIC RESEARCH

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INTRODUCTION

The most striking characteristic of Senegal's Basse Casamance region is its lowlands. About 40% of the area (300,000 ha) is comprised of a complex of the stream beds, inland valleys, and intertwining tributaries of the Casamance River. The role of these lands and tributaries in the traditional economy of the Diola people is primary. They have provided a network for transport and communication, fertile fishing grounds and sites for the collection of shellfish, and most important, they continue to represent the preferred zones for cultivating rice, the staple food.

The on-going drought has brought about dramatic changes in the region's hydrology. Salt toxicity has had a devastating effect on the characteristic mangrove swamps.[1] In some villages, farmers have been forced to abandon large portions of former rice-growing areas. In others, different cultural practices are being adopted, notably the use of direct-seeded rather than transplanted rice.

From the mouth of the Casamance river to the upper reaches of the inland valleys, the lowlands are being transformed. This document contains a synthesis of the agronomic research program conducted by the Farming Systems and Technology Transfer team during a four-year period (1982-1985). The research focused on the production of transplanted aquatic and direct-seeded phreatic rice in the Basse Casamance.[2] There were two general objectives:

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[1] ORSTOM researchers estimate that about 80% of the mangrove areas of the Casamance were rendered unproductive between 1967 and 1985 (Loyer et al., 1988).

[2] Throughout this document, direct-seeded rice refers to rice sown directly in lowland fields which flood late in the production cycle; it is also called phreatic or transitional zone rice. The term aquatic rice refers to rice which is transplanted into paddies after flooding occurs.

1) To describe and explain the cultural practices of regional farmers in the lowland areas by means of experimental trials and surveys conducted on their own farms.

2) Based on the former, to identify which extension themes were most productive and help set a new research agenda.

The document is divided into three parts. The first part gives a description of the environmental setting, the research methodology employed and the results of four years of monitoring a sample of farmers' fields. The second part discusses the results of experimental trials conducted during the same period. The last part presents the conclusions and recommendations that emerge from integrating the survey and trial results.

PART ONE:

AGRONOMIC SURVEYS AND ON-FARM TRIALS

I. OVERVIEW OF THE RESEARCH ENVIRONMENT

A. Physical Environment

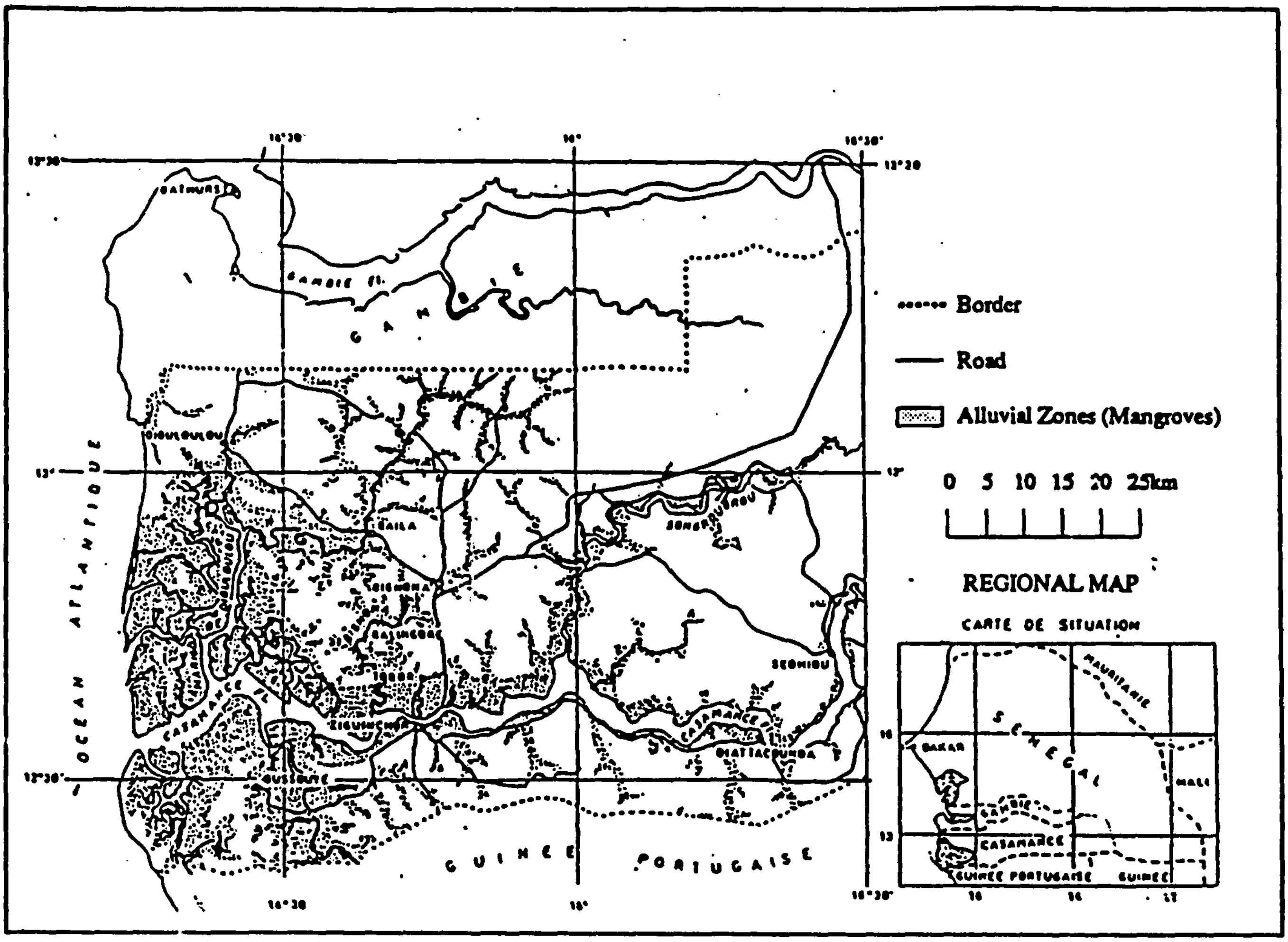
The Ziguinchor Region is situated in southern Senegal at 12-13 degrees North latitude and 16-17 degrees East longitude (see Map 1). The climate is classified as dry Guinean savanna. The region is subdivided into three administrative departments: Bignona, Ziguinchor and Oussouye. As can be seen in Table 1, lowlands can be found throughout the region and predominate in the department of Oussouye (67%). It is this dominant geographical characteristic which explains the name commonly used for the region, Basse or Lower Casamance. Historically, these areas have been very productive.

However, for the last twenty years, low rainfall (Figure 1) has had a serious effect on rice production in this area, particularly in the departments of Bignona and Oussouye (Table 2). The decline in production between 1960-64 and 1980-84 can be attributed to the high proportion of rice fields that have been abandoned (approximately 50%) as a result of salt intrusion on the lowest fields and drought stress on the upper paddies. As can be seen in Table 3, estimations made by Martin in 1958 during a period of normal rainfall (cited by Chabrolin and de Coene, 1966) indicate that historically a large proportion of the rice was grown on low-lying fields affected by the ocean tides. Today these fields are not cultivated.

The rainfall deficit and reduced area under rice have resulted in a high rate of out-migration of rural Casamance youths for the cities (van Loo, 1973; de Jonge et al., 1976; Harza, 1984).[3] It has also led farmers to begin changing their approach to farming. An expansion of dryland crops such as groundnuts, millet and corn has been apparent over the course of the last few years (ISRA, 1982; Posner et al., 1985). In the case of rice, farmers have opted for short cycle varieties and have begun adopting direct seeding. This trend is being reinforced by the local extension service (PIDAC) through several programs:

---

[3]The rate of increase of the rural population in the Casamance is estimated to be between 1.5 and 2%, while the rate for Senegal overall is 2.8% (Bonnefond and Loquay, 1985). Furthermore, the age pyramid in Casamance villages is particularly skewed toward the very old and very young, groups which, in terms of agricultural tasks, are less productive than adults between the ages of 16 and 55 years old.



Source: J. VIELLEFON: Les sols de mangrove et des tannes de Basse Casamance (Senegal). Memoire ORSTOM, N 83, Paris, 1977.

Map 1

FLOOD PLAINS OF THE LOWER CASAMANCE

TABLE 1

VEGETATION COVER, ZIGUINCHOR REGION, SENEGAL: RELATIVE DISTRIBUTION (%) OF VEGETATION COVER

Land Use	Departments: Bignona	Departments: Ziguinchor	Departments: Oussouye	Ziguinchor Region
Forests	30	30	15	29
Savanna	8	7	10	8
Cultivated and Fallow Fields	24	23	8	22
Cleared Valleys	13	20	22	15
Mangroves, Barren Low Lands	18	9	28	18
Surface Water	7	8	17	8
Total Area (ha)	529,500	115,300	89,400	734,200

Source: Plan Directeur du Développement Rural pour la Casamance. Tome IV (1978), SOMIVAC. Cited in Harza, 1984.

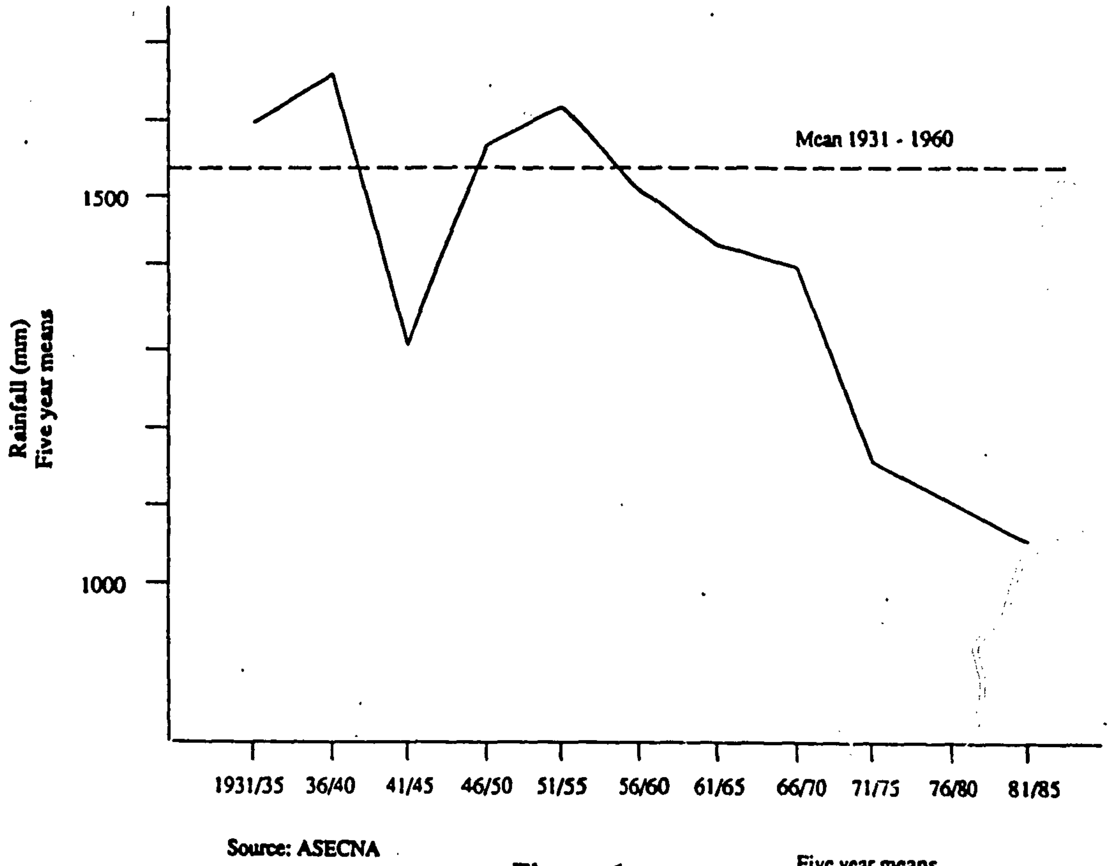


Figure 1

LONGTERM CHANGES IN RAINFALL
ZIGUINCHOR, SENEGAL
1931 - 1985

TABLE 2

AREA (HA) IN RICE PRODUCTION IN THE DEPARTMENTS OF BIGNONA, ZIGUINCHOR, AND OUSSOUYE - MEAN YIELDS 1960-64 AND 1980-84

	DEPARTMENTS									
	Bignona			Ziguinchor			Oussouye			
Years	Area (ha)	% Total[a]	Rainfall (mm)	Area (ha)	% Total[a]	Rainfall (mm)	Area (ha)	% Total[a]	Rainfall (mm)	Total Area (ha)
1960-1964	21,160	30	1,254	6,589	36	1,480	11,159	89	1,580	40,908
1980-1984	8,250	23	930	6,647	32	1,111	5,957	83	1,100	20,854

[a]Percent of total area cultivated in rice.

Source: Direction Générale de la Production Agricole, Ziguinchor.

TABLE 3

AREA (HA) IN RICE PRODUCTION IN THE THREE DEPARTMENTS OF ZIGUINCHOR REGION, 1958[a]

Department	Upper Rice Fields (non-salt-affected) (ha)	Lower Rice Fields (salt-affected) (ha)	Total (ha)
Oussouye	7,659	2,961	10,620
Ziguinchor	1,679	2,798	4,477
Bignona	4,364	17,379	21,743
Total	13,702	23,138	36,840

[a]Data collected by Martin, cited in Charbrolin and deCoene, 1966.

1) The promotion of short cycle rice varieties and the use of fertilizer.

2) The introduction of mechanized rice field preparation with rototillers and tractors.

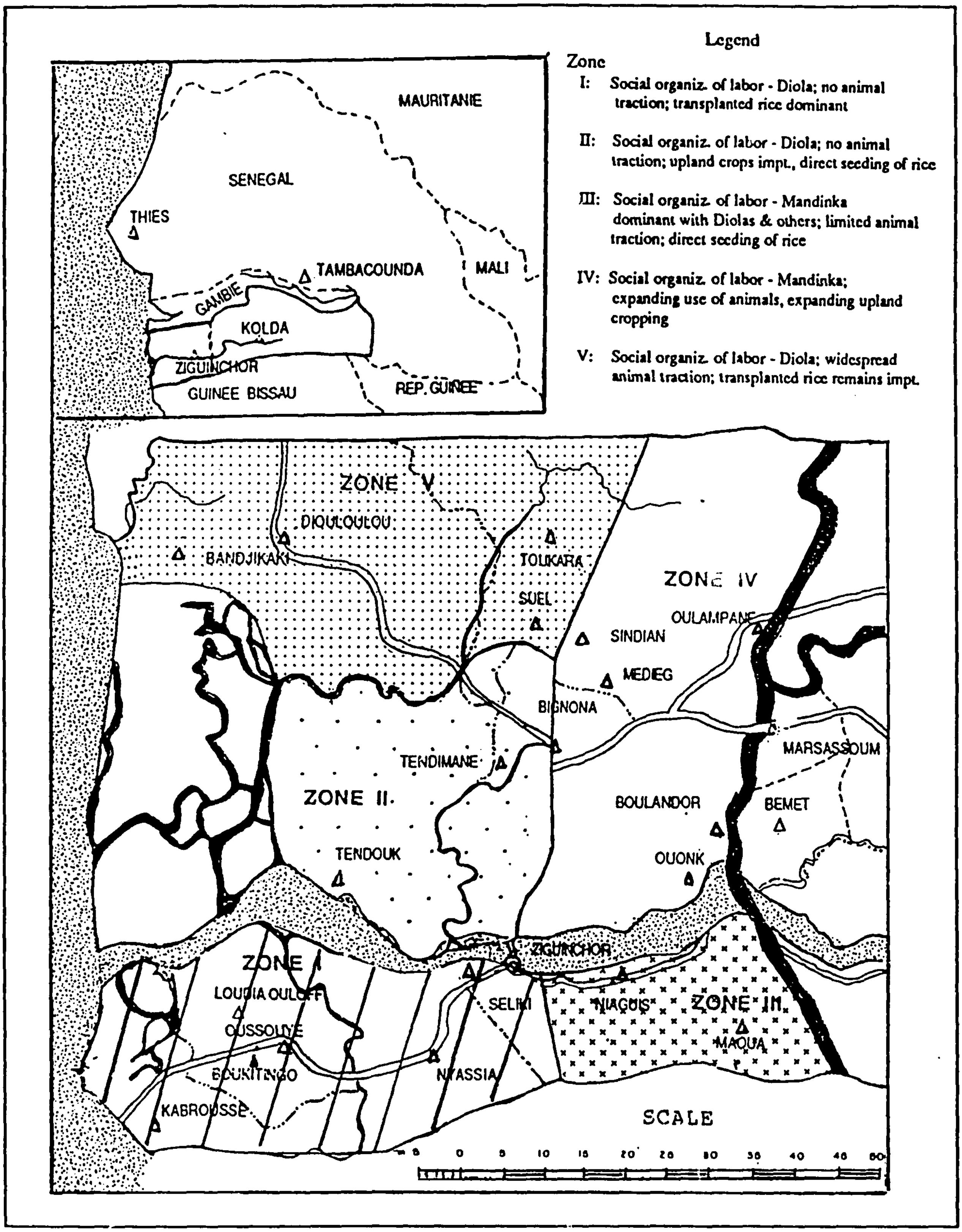
3) The construction of anti-salt dikes with gates which protect the rice fields from salt intrusion and facilitate direct seeding.

In an effort to study the production systems currently in use and how they are evolving, the research team began by dividing the Ziguinchor region into relatively homogeneous agricultural zones. From this stratification, two representative villages from each zone were selected. In each, a sample of farm families were followed for four years. The design is described in the next section.

B. Methodology

1. Zoning System and Selection of Farm Enterprises

A map delimiting farming zones was constructed on the basis of three criteria: the sexual division of labor, the extent to which animal traction had been adopted, and the importance of transplanted rice versus other cereals in the cropping system (see Map 2). These criteria resulted in five zones being identified. The team then chose two villages in each zone in order to



Map 2

MAP OF SENEGAL AND FARMING SYSTEMS ZONES IN LOWER CASAMANCE take into account the variability within zones. A random selection of between 10 and 15 farms per village resulted in a sample of 125 farms across 10 villages. These farms were studied from 1982 through 1984. In 1985, as a result of a program evaluation, the design of the surveys and trials was refined. The sample for the agronomic survey was reduced to 35 farm families in an effort to study them in greater depth.

2. Agronomic surveys

During the first phase of the work, the team employed a diagnostic survey to evaluate the local farming systems. These surveys were conceived to examine the cultural practices employed by local farmers. While the farm enterprise was the unit of aggregation, the plot under cultivation was the basic monitoring unit. In 1985, the fields being monitored were divided into subplots in order to follow more precisely changes in cultural practices used by farmers.

During the first three years (1982-84), the large sample size yielded much pertinent data concerning farming practices. Moreover, it was possible to aggregate data by farm enterprise. When the plots were subdivided in 1985, it was hoped that greater precision would be obtained on the smaller sample. Appendix 1 presents a table which summarizes the number of plots monitored each year. One can see that for the period 1982-84, the surveys focussed on an area of considerable size (60-125 ha) as well as a large number of plots (480 to 760).

3. Organization and Management of the Trials

The rice trials (Table 4) were conducted both on-station (Djibélor--25%) and on farmer's fields (75%). The protocols were discussed in detail with the research assistants and farmers responsible before putting in the trials. The orientation included the overall design, objectives, experimental methodology, and anticipated results of the study as well as the role the farmer would play in carrying out cultural practices (soil preparation, planting, fertilizer and insecticide applications, etc.). The research assistant worked with the farmer in carrying out this work and collected information on events which transpired during the growing season which would clarify the farmer's constraints in following the protocol. The number of collaborating farmers by type of trial varied between three and five from one village to another.

TABLE 4

AGRONOMIC TRIALS CONDUCTED IN THE LOWLAND AREAS (1982-85)

	Years			
	1982	1983	1984	1985
A. Aquatic (transplanted) Rice Zone				
Varietal trials[a]	X	X	X	X
Desalination of rice fields monitoring	X	X	X	X
Plowing and drainage study-effect on the desalination of the flood plain[b]			X	X
Type of planting-comparison of direct seeding and transplanting	X	X	X	X
Relay cropping sweet potatoes after aquatic rice	X	X	X	X
B. Transitional (direct seeded) Rice Zone				
Varietal trials[a]	X	X	X	X
Fertilizer trial	X	X	X	X
Herbicide trial[a]		X	X	X
Seeder test			X	X
Relay cropping sweet potatoes after direct seeded rice		X	X	X

[a]Conducted with Rice Team ISRA/Djibélor

[b]Conducted with the Watershed Development Team, ISRA/Djibélor. See 1984, 1985, 1986 annual reports on "Aménagement des Bolongs".

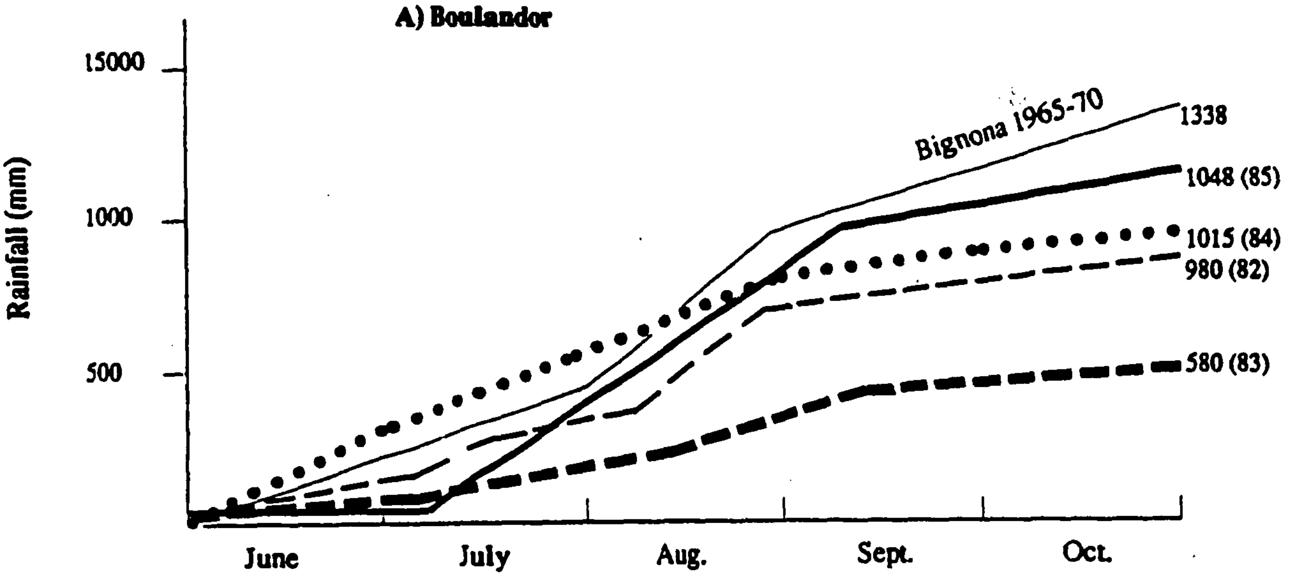
C. Rainfall: 1982-1985

It is important to understand the annual rainfall pattern and its variability during the four years studied. It places the villages within the context of the present drought in the Sahel as well as characterizing the different moisture conditions prevailing during each agricultural season at the study sites. The study villages on the south and north banks (Loudia-Ouoloff and Boulandor, respectively) of the Casamance River will be considered separately. The cumulative precipitation curves are shown in Figure 2.

At Boulandor, the total rainfall was very variable across the four rainy seasons considered (580 to 1,048 mm). Each year, as the flattened curve implies, there were lengthy dry spells which affected the crops. The total rainfall in 1982 was close to the average of the previous 15 years (944 mm); 1983 by contrast was the driest year registered on the north bank. In 1984, a year with abundant rainfall, June and July were so wet that temporary flooding occurred in a number of maize fields resulting in below average yields. Despite a slow start of two to three weeks in 1985, the months of July, August and September received above average rainfall with a good distribution. Although the total was similar to that of 1985, it fell in three rather than four months so did not have the intermittent dry spells that were experienced during the previous years. Most important, there was sufficient run-off to flood the rice paddies.

At Loudia-Ouoloff on the other hand, the total rainfall was much less variable both across and within years. The crucial final rains which fall in October give the rice enough moisture to complete its cycle. In 1982 and 1983, the heavy rains of the third week in August (232 and 212 mm) filled the rice paddies and thus permitted transplanting of aquatic rice The rainfall and its distribution in 1984 was even better. In contrast, 1985 proved to be a the worst year of the series in the Department of Oussouye. Loudia Ouoloff received only 897 mm. Transplanting was late because of the low rainfall received through the end of August (620 mm), and the heavy rains received in early September (194 mm in six days). To make matters even worse, from the 20th of September on, there was only 53 mm of rainfall.

Successful growth of aquatic rice under tidal conditions is determined by the decreasing concentration of the salt in the tributaries of the river



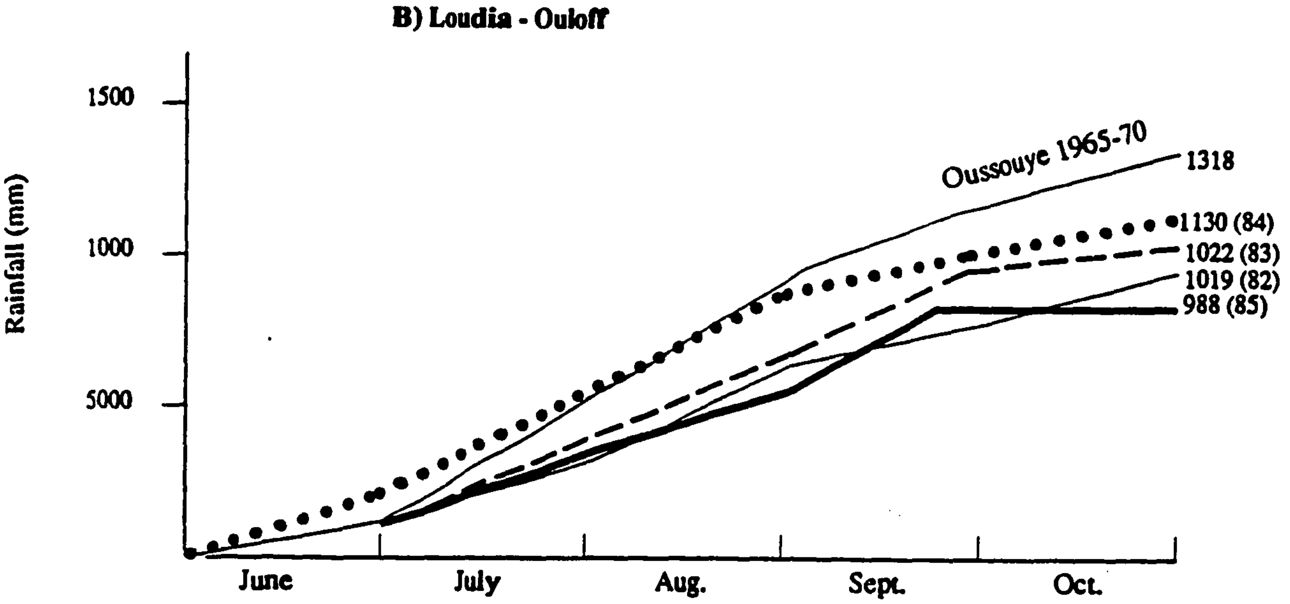


Figure 2

CUMULATIVE RAINFALL FOR 10 DAY PERIODS - 1982-85 SEASONS NORTH BANK (BOULANDOR) AND SOUTH BANK (LOUDIA-OUOLOFF) OF THE LOWER CASAMANCE.

estuary (bolongs) during the course of the rainy season. Figure 3 traces the change in salt levels of the Soungrougrou bolong at Boulandor and of the Diakon bolong at Boukitingo for three rainy seasons (1983-85). In both places the water in the bolongs is as salty as the ocean (the conductivity level was higher than 60 mmho/cm^2) from the end of November to mid-July. From July on, depending on the rains, the water desalinates at different rates. At Boulandor, in a dry year (1983), the Soungrougou remained salty throughout the summer; even in a wet year like 1985, a "window" of sweet water was only apparent (CE < 5 mmho/cm^2) during the last 15 days of August. In contrast, at Boukitingo, which has less salt accumulation during the off-season as well as greater average rainfall during the growing season, the river water became desalinated every year during the month of September. Even so, during the three years monitored, neither site obtained adequate ràinfall to permit a good environment for mangrove rice cultivation.

To conclude, during the period studied, the rainfall pattern on the north and south banks was quite variable. On the south bank, where transplanted rice predominates, sufficient rainfall is required in September and October in order to achieve an adequate harvest. For the north bank villages, based more on upland cropping and direct-seeded rice, an early beginning as well as a good distribution of rain throughout the season are the important characteristics of a good year. In general, the four years studied were not ideal in either of the two ecosystems.

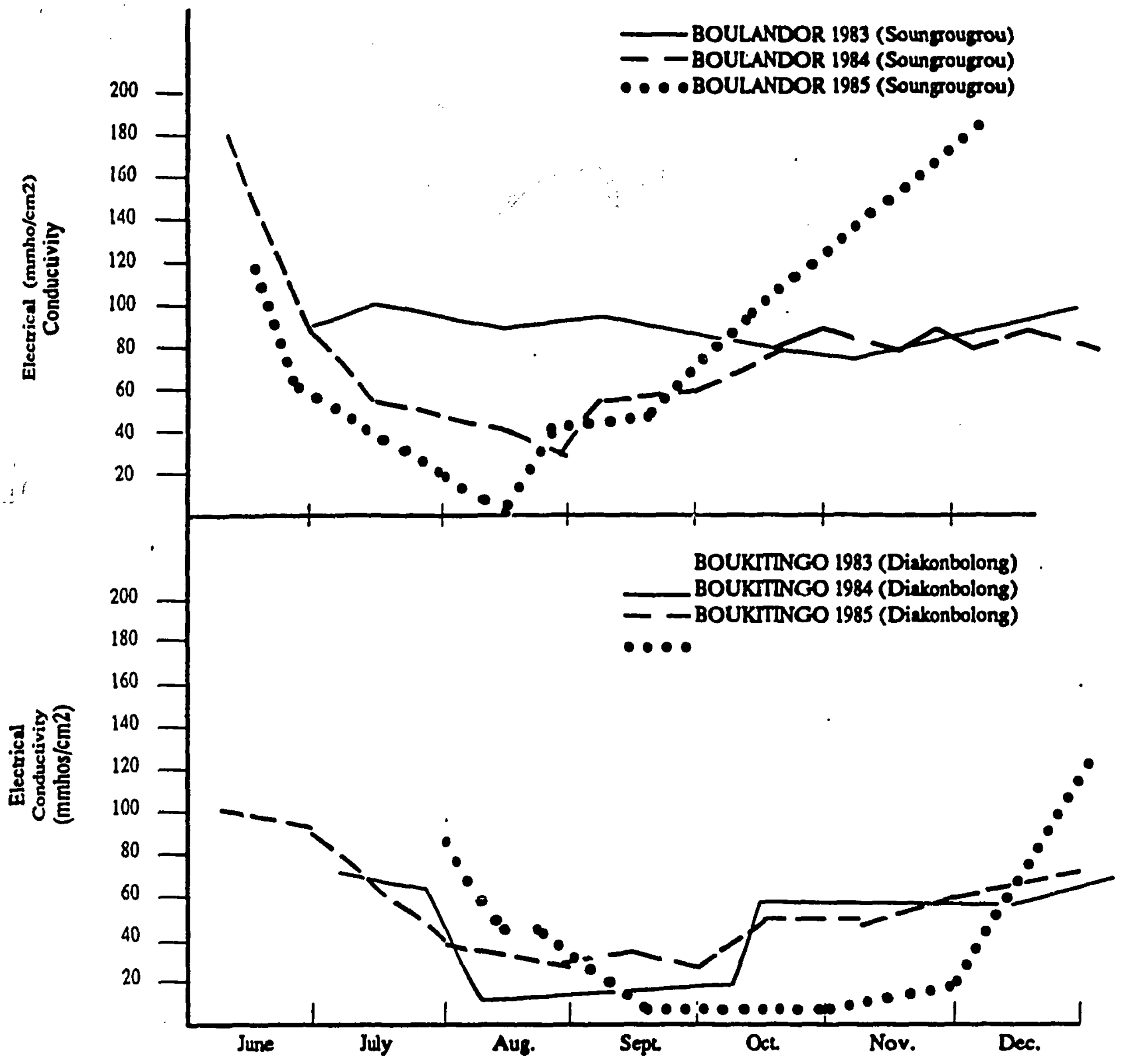


Figure 3

CHANGING SALINITY CONCENTRATIONS (mmhos/cm2) OF THE RIVER WATER AT TWO SITES IN THE LOWER CASAMANCE

II. LOWLAND CROP PRODUCTION

A. Typology of Rice Production Situations

After four years of monitoring plots at the study sites and gathering information on an informal basis in other villages, three lowland rice production systems were identified in the Basse Casamance. Table 5 shows, in terms of percentages, that in Zone I aquatic rice (transplanted) is dominant in all the villages in the sample. At the other extreme, in Zone IV only a small proportion of the rice is transplanted. Between the two modes--transplanting and direct seeding--variable strategies were observed which depended on the rainfall obtained during the year in question. As a first approximation, three types of village situations can be described:

1. Villages where generally only transplanted rice is grown. This is the case in Boukitingo and Mangagoulak where rice farming is very labor intensive (manure is transported and two plowings take place). In contrast, there are other villages, also based on aquatic rice, in which the crop is not as well tended for various reasons. Seleky is a case in point. In this village, aquatic rice fields are so numerous that the farmers do not have enough time to care for them properly. At Loudia-Ouoloff, the quest for other sources of revenue (from non-agricultural activities), is one of the factors which explains why efforts devoted to aquatic rice are limited. At Mahamouda[4] and Bandjikaki[5] the importance of other upland cereals has led to less intensive aquatic rice culture.

2. Villages where, since 1982, direct seeding of rice has been dominant. Only five or ten years ago, transplanted rice predominated at Tendimane, Boulandor and Suel. Today, direct-seeded rice is more common. Further north, direct-seeded rice was always important (Toukara and Medieg). However, the situation is not rigid. For example, in Tendimane a large downpour in the beginning of July 1985 inundated the rice fields, prompting the farmers to also transplant with seedlings thinned from the first direct-

[4]Near Mahamouda, PIDAC (the local development agency) completed contruction of an anti-salt dam in 1983. Some women in the village have benefitted and are able to plant direct seeded rice up stream from the dam.

[5]At Bandjikaki in 1984 there was a special PIDAC project to promote direct seeded rice which explains the sudden change in proportions.

TABLE 5

DISTRIBUTION OF AREA IN RICE IN THE LOWER CASAMANCE BY TYPE OF PLANTING AND VILLAGE STUDIED (1982-85)

		Proportion of Rice Area By Type of Planting (%)							
Farming Systems Zones	Villages	1982		1983		1984		1985	
		TR	DR	TR	DR	TR	DR	TR	DR
I	Loudia-Ouoloff	100	0	100	0	100	0	92	8
	Boukitingo	100	0	100	0	100	0	100	0
	Seleky	NM	NM	NM	NM	NM	NM	92	8
II	Mahamouda	100	0	75	25	90	10	NM	NM
	Tendimane	0	100	0	100	0	100	77	23
III	Boulom	67	33	58	42	41	59	NM	NM
	Maoua	16	84	15	85	28	72	33	67
IV	Boulandor	17	83	0	100	6	94	30	70
	Medieg	23	77	31	69	8	92	NM	NM
V	Bandjikaki	100	0	100	0	0	100	72	28
	Suel	NM	NM	0	100	13	87	4	96
	Toukara	NM	NM	NM	NM	NM	NM	0	100

TR - Transplanted rice

DR - Direct seeded rice

NM - Not monitored

seeded plots. Thus the course of the rains will determine the strategy that the farmers will follow in the future.

3. Villages where the distribution of rice plots is linked more to ethnic affiliation or neighborhood than to rainfall. This is true of rice on both salt-affected (aquatic) and non-salty areas (aquatic and phreatic). In the case of Maoua and Boulom (Zone III) certain families cultivated the aquatic, salt affected fields and entirely different families farmed in the nearby freshwater inland valleys.

The farmers of the Lower Casamance are still culturally attached to transplanted rice, but the climatic conditions experienced in recent years do not ensure its success everywhere. In the Oussouye area, the zone with the most water as well as the largest proportion of lowlands, it is not surprising that farmers persist in transplanting rice. Moreover, in this zone, the farmers do not have sufficient upland areas suited to the cultivation of other crops, such as millet, corn or peanuts. For this reason, their primary adaptation to the drought has been to regulate the areas transplanted to rice according to the rainfall pattern they observe each year (Posner et al., 1985). They then devote more or less time to non-agricultural activities such as fishing, basketry and gathering fruits as a source of supplementary income. On the other hand, in villages of the second type, the farmers have adapted to the drought by moving from transplanted to direct-seeded rice and devoting more time to upland fields. Villages in the third category are more complicated as the distribution of rice fields across the toposequence is a function of ethnicity or neighborhood. Moreover, those who farm the salt-intruded valleys have little option but to transplant their rice.

B. Classification of Rice Fields

1. Characterization of Rice Soils

A schematic drawing of the Basse Casamance countryside is shown in Figure 4. Upon leaving the plateau, one first encounters the inland valleys where rice is grown under palm groves (transitional gray soils) or next to the stream beds. Approaching the Casamance River or one of the bolongs (tributaries), one finds another belt of transitional soils followed by the very sandy, upper rice fields (old alluvial terraces). Next are the soils of the actual flood plain, which have marine and alluvial deposits juxtaposed with inclusions of colluvial deposition. When they are cultivated (tilled,

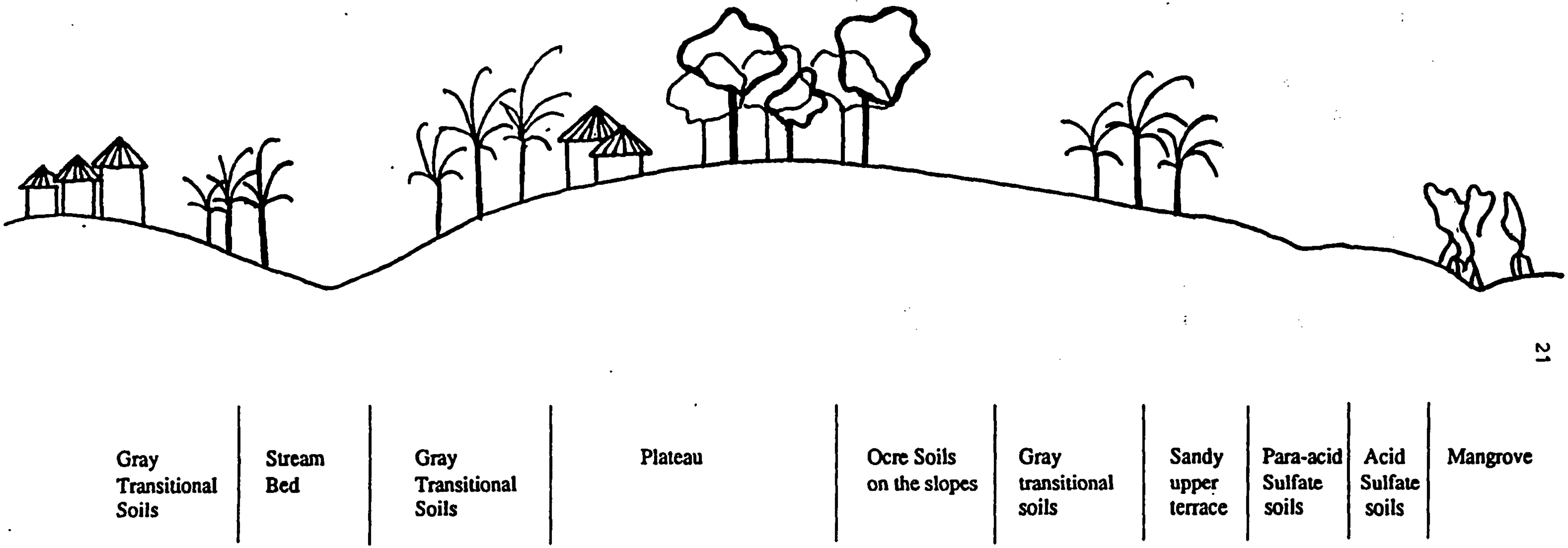


Figure 4

DIAGRAM OF THE TYPICAL TOPOSEQUENCE IN LOWER CASAMANCE

enclosed by dikes), these soils are often transplanted to rice. Following this zone, one encounters stretches of barren land (tannes in Wolof, meaning place where nothing grows) with their extreme salinity and acidity (acid sulfate soils). Last are the deep rice paddies found on mangrove soils (potentially acid sulfate) which are inundated by the changing tides (Table 6).

2. Local Nomenclature for Types of Rice Fields

From the mangrove swamps to the valleys at the headwaters of the tributaries, the farmers try to grow rice. The most important factor as far as they are concerned is the elevation of the rice field, since that determines the flooding pattern.[6] Local names for the fields vary from one village (or zone) to another but certain terms have the same semantic roots for a particular position in the toposequence.

Table 7 gives the local names for rice fields in the study villages. At Boukitingo, Loudia-Ouoloff and Seleky (in the Oussouye zone), all transplanted rice is grown on the flood plains (the Diola names for these rice fields are huligne, hugnanke and hukegue). In contrast, at Tendimane in the Bignona valley and Boulandor in the Soungrougrou valley the rice fields at the same topographic position--the alluvial plain--(called upokulo and bitaku) are currently being direct-seeded. Situated on higher ground, at Medieg, Suel and Toukara, where the soils of the inland valleys are farmed, women plant rice directly in the highest areas (kasiluk), and in a wet year, transplant rice in the stream beds (koyake).

The lowest rice fields remain the preferred zones for aquatic rice. Two thirds of these areas were put into transplanted rice in 1984. The other

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[6]For the Diola farmer, rice field characterization can be understood best in terms of the number of weeks of flooding. Consider the case of Boukitingo:

Number of weeks of flooding (Boukitingo)

Year	Upper Paddy	Middle Paddy	Lower Paddy	Annual Rainfall (mm)
1984	2.5	2.8	7.3	1,073
1985	2.5	4.1	6.3	1,159

TABLE 6

SOIL CHEMICAL CHARACTERISTICS (0-10CM)
OF THE RICE FIELDS IN LOWER CASAMANCE[a]

Types of Soil	Sites	Texture (%)			pH	Organic	CEC meq/	Base Saturation
		Clay	Silt	Sand	(1:2.5)	Matter (%)	100gm	(%)
Transitional soils gray	Djibélor	8	6	86	4.5	0.8	-	-
Valley Bottom soils	Djibélor	48	15	37	4.8	6.0	11.7	60
	Medieg	8	4	88	4.5	2.7	-	-
	Maoua	40	35	25	4.6	9.5	20.4	11
Upper rice fields	Djibélor	6	2	92	4.6	2.3	1.2	75
Flood plains sandy	Djibélor	24	6	70	3.9	0.9	7.8	82
clay	Djibélor	50	17	33	4.8	4.0	11.4	22
Mangrove	Soukouta	69	27	4	4.8	3.4	-	-

[a]Soil analyses conducted at the Djibélor lab.

TABLE 7

LOCAL TERMS FOR RICE FIELDS

Toposequence	Villages									
	Seleky	Boukitingo	Loudia-Ouoloff	Bandjikaki	Tendimane	Boulandor	Maoua Boulom	Suel	Medieg	Toukara
Inland valleys										
Valley head				Ekinke				Huisse		Ekinke
Under Palm Grove							Santo-faro	Kulenene	Kassiluk	
Stream Bed		Hussule	Hussirrene	Kassine			Duma-faro		Koyak	
Flood Plains										
Upper Fields	Ugunorr	Huligne	Hutiatia		Ufumau	Kufessaku				
Plains	Gulotte	Hugnanke	Hugnanke	Katima	Upokule	Bitabu				
"Tanne"[a]	Guafinte	Hulinte	Kahinte	Hahite	Kafinte	Sikanassu	Leto-faro			
Mangrove	Gutite	Hukegue	Hukegue	Kuname	Utambeu					

[a]Barren land

third was reserved for direct-seeded rice. In upper fields on the other hand, approximately three-quarters of the rice is direct-seeded (see Table 8a). The drought has led farmers to abandon the uppermost areas (for lack of water) as well as lowest fields (because of salt intrusion) and to focus on the intermediate regions. Of 83.01 ha of rice monitored in 1984, half were in the intermediate zones of the toposequence.

Yields of transplanted rice are higher in the lower paddies than in the upper paddies (see Table 8b) since more water is available. For direct-seeded rice, however, the elevation of the field is not as important, as planting occurs early and the varieties have a shorter cycle.

The average yields given in Table 8b, for aquatic rice in particular, reflect the adverse effect of salt intrusion (Loudia Ouoloff and Boukitingo) and iron toxicity (Loudia-Ouoloff, Maoua and Tendimane).[7] Fields affected by these conditions did not produce more than 400 kg/ha on average, compared with an average 1,200 kg/ha obtained on most good fields. The indigenous descriptive terms for rice fields do not take soil texture into account. This makes sense because in any given village, the rice fields at a particular elevation in the toposequence generally have the same texture since their soils were deposited by water. This is why the huligne fields at Boukitingo are higher and sandy while the hukegue in the mangroves are lower and heavy.

As might be expected, the lowest yields are found in the areas where soils are the lightest, both in the transitional as well as the aquatic zones (Table 9). With respect to the heavy soils, the relation is not as clear. In the transitional zone, the best yields tend to be on heavy clay soils, but in the aquatic rice areas, the same heavy soils which are often the richest in chemical composition also have the highest levels of salt and iron toxicity.

3. Scientific Classification of Rice Fields

The classification of rice fields and varieties of rice developed by WARDA (the West African Rice Development Association) and ISRA (Senegalese Agricultural Research Institute) is very similar to that used by the farmers of the Lower Casamance. What is known to the farmers as Pam-Pam rice and grown on recently cleared lands corresponds to classical rainfed rice in the nomenclature adopted by agronomic researchers. The defining characteristic of

[7]In 1984, the problem of salt intrusion was noted on 20% of the aquatic rice fields studied. Iron toxicity was apparent in 9% of aquatic fields.

TABLE 8

DISTRIBUTION OF AREA (A) AND YIELD (B)
OF RICE FIELDS BY POSITION IN THE TOPOSEQUENCE

A. Distribution of Area in Rice by Toposequence Position and Planting Method (%) 1984

	Toposequence Position			
Planting Method	High	Intermediate	Low	Total (ha)
Direct Seeded	77	57	37	45.11
Transplanted	23	43	63	37.90
Percent Total Area	24%	47%	28%	83.01

B. Average Yield (kg/ha) of Paddy by Position in the Toposequence

		Toposequence Position			
	Years	High	Intermediate	Low	F-test
Direct Seeded	1983	364	711	817	9.1[c]
	1984	708	973	991	3.6[b]
	1985[a]	1,284	1,269	1,124	NS
Transplanted	1982	691	1,352	1,446	17.5[c]
	1983	500	570	1,021	11.6[c]
	1984	460	543	851	6.3[c]
	1985[a]	530	1,130	1,079	8.4[c]

[a]1985 based on 7 villages studied for four years

[b]Significance level = 5%

[c]Significance level = 1%

NS = Not Significant

TABLE 9

AVERAGE YIELD (KG/HA) OF PADDY BY SOIL TEXTURE

Mode of Planting	Texture	Yield (kg/ha) 1983	1984
Direct Seeded	Sandy	274	428
	Loamy	577	797
	Heavy	850	1,219
	F-test	8.7[b]	18.06[b]
Transplanted	Sandy	450	618
	Loamy	890	758
	Heavy	650	612
	F-test	6.3[b]	NS

[a]Significant at 5% level

[b]Significant at 1% level

NS = Not Significant

strictly rainfed rice is that water does not accumulate on the fields. For this reason, short cycle varieties (90 days) are required. Near the borders of the valley stream, zones of phreatic rice (Santo Faro, Kufessane, Kassiluk) are apparent. The water table rises for a short period in August and September supplying additional moisture to the fields. Since these fields have more moisture, 110-day varieties can reach maturity. In the stream beds of the inland valleys (Huligne, Duma-faro), at least in rainy years, one finds deep flooded rice fields for which rapidly elongating, long cycle (145 days) varieties are recommended.

The flood plain is the most affected by the rainfall deficit. Thus the rice fields at Boulandor, Bandjikaki and Tendimane, historically fields which are transplanted and which can be classified as shallow flooded (by the agricultural research definition), are currently direct-seeded rice fields in most years, depending on the water table for moisture. Only in the Department of Oussouye do farmers continue to transplant rice in the shallow paddies; further down the toposequence, where the problems of soil acidity (tanne), and salt intrusion (tanne and mangroves) are critical, the fields are generally abandoned.

In Table 10, the indigenous and research classifications of rice fields are contrasted. In a concluding section of this paper, another categorization will be proposed. The new system is more agronomically based, focussing on current mode of planting and field preparation rather than on the historical level of flooding.

C. Rotations

Flooded land is used for one purpose during the rainy season--to grow rice. In some areas, however, winter season crops such as sweet potatoes and vegetable gardens are being grown. These activities are becoming more important but still only concern 13% of the fields studied in 1984, the last year of the original sample. Dry season farming was observed in Maoua and Loudia-Ouoloff (sweet potatoes) and Boulom (gardening). Sweet potatoes require much less care than gardening and can be grown on lighter soils. If the water table is shallow (less than 100 cm) and if transplanted early (beginning of November), the crop can succeed even without watering. On-farm and station trials show yields in the order of five to ten tons/ha of marketable sweet potatoes. In contrast, gardening requires much more attention and

TABLE 10

LOCAL TERMS AND RESEARCH CLASSIFICATION FOR TYPES OF RICE

ISRA/WARDA Classification		Local Classification	
Classification	Recommended	Local Name	Local Variety Variety
1. Strict Rainfed Rice	144B/9	Riz "Pam-Pam"	Barafita
2. Rainfed Rice-Assisted by the Watertable	144B/9 IRAT 133 IRAT 112 DJ-12-51	Santo-faro Kufissaku Kassiluk Ufumau	Barafita Adboulaye mano Bassite Bilikissa Senecoly Kuboni Liano
3. Aquatic Rice-Shallow			
a. Inland Valley	IR1529, BR-5 IR-8	Dumo Faro Koyake	Abdoulaye mano
b. Flood Plain	DJ-684D ROK5	Gufot Hugnanke Upokule	Senicoly Diamisse Mpak Essoboro
4. Aquatic Rice-Deep	IR 442 Apura	Duma Faro Koyake	Ehog Kagnoye

consistent watering. Generally, gardens are grown on heavy soils and necessitate the construction of many shallow (1-2 m) wells to maintain them.

The effect of cool season farming on the summer rice crop is not uniform. Manure application on the garden plots has a positive effect while sweet potatoes which are not fertilized seem to reduce rice yields the following season (see Table 11). One positive aspect of growing sweet potatoes is that uprooting them at harvest serves also as a form of primary tillage for the next rice crop.

TABLE 11

EFFECT OF COOL SEASON CROP ON SUBSEQUENT RICE YIELDS (KG/HA)-1984

Cool Season Crop Winter 1984	Rice Yield Loudia-Ouoloff	(kg/ha) Boulom	Maoua
Fallow	776	1,045	327
Sweet Potato	478	-	205
Garden	-	1,698	-
F-Test	NS	6.89[a]	NS

[a]Significant at 1%

NS = Not significant

D. Distribution and Size of Plots

Area cultivated in lowland rice per farm varied from 0 to 130 ares (Table 12). The typical farm family cultivated between 36 and 75 ares of rice with the exception of Boulandor where several households remain under the leadership of a patriarch and therefore constitute one larger farm. Because of the drought, the aquatic zone has become smaller; in several villages where

TABLE 12

AVERAGE TOTAL AREA OF RICE FIELDS IN TRANSPLANTED (TR) AND DIRECT SEEDED RICE (DR) BY FARM 1982-1985 (IN ARES)

Villages	Mode of Planting	1982	1983	1984	1985[a]	Average per Village[b] (ares)
Loudia-Ouoloff	TR	85	71	81	89	69.0
	DR	0	0	0	8	
Boukitingo	TR	45	45	52	63	47.3
	DR	0	0	0	0	
Mahamouda	TR	46	18	35	NM	36.3
	DR	0	6	4		
Tendimane	TR	0	0	0	61	40.3
	DR	56	27	38	18	
Boulom	TR	68	35	27	NM	75.3
	DR	33	25	38		
Maoua	TR	18	9	21	23	82.3
	DR	91	53	55	48	
Boulandor	TR	20	0	7	36	113.3
	DR	101	89	123	85	
Medieg	TR	18	19	6	NM	69.0
	DR	58	43	63		
Bandjikaki	TR	93	37	0	54	45.0
	DR	0	0	5	21	
Suel	TR	NM	0	5	2	37.5
	DR		31	39	49	
Mean		81	51	60	80	

[a]In 1985, only 3 to 5 farms per village were studied.
[b]Average for 1982, 1983 and 1984.
NM = Not monitored

aquatic rice is still central, farmers only cultivate one or two plots[8] (see Table 13a). With respect to the transitional zone, the average number of plots under cultivation is at least three, as is shown in Table 13b. Fields are then often divided into a number of subplots delimited by small retaining dikes constructed to facilitate water spreading.

More than 30% of the rice fields followed are more than 15 ares, and 85% are more than 5 ares (Table 14). In certain villages (Boulom, Maoua, Boulandor, Medieg, Suel and Bandjikaki), because plots are somewhat larger, the use of mechanized equipment (animal traction, tractors) for land preparation would not pose an insurmountable problem.[9] (See Appendix 2 for the average size of plot by village.)

E. Land Preparation

1. Tillage with the Cayendo

Land preparation with the cayendo (see Appendix 3 for a description of this tool) is almost always done by the ridge and furrow method. Before the present drought cycle, farmers often tilled their plots twice; once after harvest to incorporate the rice stubble, and a second time in August just before transplanting. This last tillage occurred in two stages. First the ridge is split into two sections extending the length of the row, filling the furrows of the previous year. Then, the old ridges are excavated becoming the new furrows and the soil is used to build the new ridges.

Today this type of tillage is no longer practiced as the fields are already dry in February, with the exception of those under the direct influence of the tides. It is in these areas that the Diola farmer is still able to create ridged rice fields in the traditional way. However often even these fields are not tilled during the dry season as before. Farmers argue that this is not as necessary now since weed growth is less of a problem due to excessive salt accumulation in the dry season.

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[8]The exceptions are Boukitingo and Seleky, two older villages where farmers continue to cultivate five to ten transplanted rice fields.

[9]At Boulom, oxen and roto-tillers are already employed in the rice fields while at Boulandor, ox-pulled seeders are in use. However, even if the dimension of the plots were to allow for mechanized land preparation, there are other problems which might well complicate mechanized plowing such as the configuration of the plots and lack of access to them.

TABLE 13

NUMBER OF PLOTS PER FARM IN LOWLAND AREAS - 1984

A. Aquatic Rice - Number of Compounds

Number of fields	Loudia-Ouoloff	Bouki-tingo	Boulom	Maha-mouda	Seleky[a]	Total (%)
0	3	1	0	2	0	10
1	6	0	3	5	0	23
2	4	3	3	5	0	25
3	0	4	4	0	0	13
≥ 4	2	7	2	3	4	29
Total	15	15	12	15	4	

B. Phreatic Rice - Number of Compounds

Number of fields	Boulom	Maoua	Boulan-dor	Medieg	Suel	Tendi-mane[b]	Total (%)
0	2	1	0	0	1	0	5
1	1	1	0	0	4	3	10
2	0	3	0	0	4	7	16
3	2	4	1	2	2	5	19
4 to 6	8	6	6	8	4	0	37
>6	2	0	5	4	0	0	13
Total	15	15	12	14	15	15	

[a]Results of the 1985 agricultural season

[b]Due to the natural slope at Tendimane the belt of rice fields which are high enough to be unaffected by salt, but low enough to be sufficiently wet, is very limited. This explains why there are no farms which contain more than three rice fields in the phreatic zone.

TABLE 14

PERCENT OF FIELDS BY SIZE CATEGORIES IN THE LOWLANDS OF THE ZIGUINCHOR REGION

Plot Size (ares)	Aquatic Rice		Phreatic Rice	
	1983	1984	1983	1984
0-5	14	15	21	19
6-15	47	39	56	58
16-25	20	24	18	17
26-50	12	14	4	5
+51	7	8	1	1

Farmers have adopted several different approaches to tilling the paddies that still remain in cultivation. Consider the following:

a) At Boukitingo and Mangagoulak, the farmers always till two times (in 92% of the cases) however the majority (75%) till for the first time in June with the first rains, rather than February.

b) In Loudia-Ouoloff, Mahamouda and Bandjikaki, peanuts are planted in June or July and the farmers only go into the rice fields to begin their one and only tillage at the end of August. Transplanting occurs at this time as well.

c) At Tendimane and Suel, farmers till their rice fields in July and afterwards broadcast direct-seeded varieties on the tops of the ridges.

The main purpose of ridging is to facilitate weed control and to allow better control of the depth of flooding. The cayendo turns over the weeds very well. In making the ridges and dikes, the farmer sections off the rice fields into small plots which allow groundwater, rainwater, and the tides to accumulate to a level required for the growth of the plant. In certain low areas like Katoure some of the ridges are as much as a meter high, while even in some higher fields (Seleky) farmers have sectioned off areas with tied ridges in order to improve the efficiency of water retention from run-off.

The historical role of the cayendo in swamp rice cultivation (digging drainage canals, constructing polders) is less important today than it was 20 years ago. Farmers now avoid salt-intruded zones or accept the fact that it is risky to cultivate them.[10] The problems associated with the drought (late flushing out of salts or their early reentry) are problems that cannot be resolved with the cayendo.

2. Land Preparation with the Fanting

The fanting, a long-handled hoe, is primarily a woman's tool (see Appendix 3). In the transplanted areas, women perform two tillages, one in mid-July and one before transplanting in mid-August. Fields prepared by women in this way are not ridged but frequently there is a small dike (about 20 cm) surrounding the plot. On the higher fields, direct seeding is carried out after only one tillage. The actual task includes turning over the soil, breaking up the clods, and removing the tufts of weeds before broadcasting and covering the rice seed.

3. Mechanized Soil Preparation

The use of oxen and roto-tillers to prepare rice fields, although still infrequent in the Lower Casamance (see Table 15), is beginning to make inroads. In 1985 the extension service began an ambitious project of custom roto-tilling (15,000 CFA/ha). An estimated 665 ha were prepared this way.

Use of oxen-drawn moldboard plows (see Appendix 3) is a more feasible method for local farmers. However, the moldboard plow requires moist soils (at least 150 mm of rain received) to be successful, so it cannot be used in advance of the rains. Therefore, men (who own the oxen) would have to prepare women's rice fields at a time when they are working on their own upland crops. Time won in getting a good start in the rice fields is thus lost for millet and groundnuts, the latter a cash crop. This explains why to date, in the zones where animal traction has taken hold, only the occasional transplanted

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[10]In a dry year like 1983, farmers stayed away from the salt-affected zones (only 15% of these areas were transplanted). In wet years they moved back into these fields (34% of the area transplanted) but the results were very poor (only 438 kg/ha average yield).

TABLE 15

PERCENT OF AREA TILLED IN THE LOWLAND AREAS BY TYPE OF IMPLEMENT

Implement	1982	1983	1984	1985
"Cayendo" (fulcrum shovel)	54	44	42	58
"Fanting" (long-handled hoe)	41	53	44	29
"Charrue UCF" (Ox-drawn plow)	2	2	5	8
"Motoculture" (Tractor Tillage)	3	1	10	5

field is plowed. An exception to this pattern was observed in Boulandor. There, men brought the oxen into the rice fields to plant once the plots had been prepared by their wives. This reduced women's work load and got the season off to an early start.

4. **The Effect of Land Preparation on Yield**

In the case of aquatic rice, results indicate that fields prepared by the ridge and furrow method did not yield significantly more than those that were flat plowed. It is logical that in aquatic rice fields, if flooding is adequate, the two methods of preparing the fields would result in similar yields. In transitional areas on the other hand, flat tillage appears to produce somewhat better results (Table 16). This finding should be interpreted with caution, however. In fact, no two villages in the sample can be said to have truly equivalent fields. Nevertheless, in transitional rice fields where drought stress can be a problem, the plant is closer to the water table with flat tillage, thus one would expect better results. Moreover, flat tilling results in a higher plant density than the ridge and furrow method.

Survey results indicate that approximately 20% more panicles per meter square were harvested with the former compared to the latter method.

TABLE 16

TYPES OF LAND PREPARATION AND THEIR EFFECTS ON RICE YIELDS

Type of Land preparation	Transplanted Rice Yield (kg/ha)		Direct Seeded Rice Yield (kg/ha)	
	1983	1984	1983	1984
Flat plowed	800	601	658	813
Ridge and furrow	756	756	219	210
F-Test	NS	NS	29.4[a]	17.7[a]

[a]Significant at 1% level

NS = Not Significant

5. **Labor Time**

Land preparation for rice is a slow and arduous task, taking in the order of 40 person-days/ha (based on an 8 hour day), regardless of the tool employed (*fanting* or *cayendo*). For aquatic rice, this sum includes two plowings while with direct-seeded rice it includes the two operations of hoeing the ground and then breaking up the clods of soil and pulling out the weeds. When this work is done mechanically, a great deal of time is saved. According to studies conducted by Travers (1973) plowing aquatic rice fields can be done in 8.5 days per hectare using animal traction (one man and a pair of oxen) and it takes only two days with a roto-tiller (utilizing 15 liters of fuel per hectare). Prior to plowing fallowed rice fields, the brush must be cleared. Results of surveys conducted in 1983 and 1984 indicate that clearing takes between 12 and 15 person-days.

F. Varieties

Lower Casamance is known for having a wide range of indigenous rice varieties. Farmers' knowledge about these varieties and their willingness to experiment with new varieties are important strengths for the region during this low rainfall period. A number of different varieties (more than five per village) were being utilized in many of the study villages and almost all were of recent introduction (less than 20 years) (see Appendix 4).[11] Farmers are continually looking for early maturing varieties adapted to the current shorter rainy season. The local glaberrimas, once the mainstay of the region, have virtually disappeared (an exception is "Etouhal" and "Efegore" at Seleky). One finds the entire range of varieties planted on all types of rice fields, either by transplanting or direct seeding. It appears that, in their own way, farmers are engaged in a huge screening program. As part of the program, it is not unusual to see sub-plots in good paddies planted to different varieties simply for the purpose of producing seed.

As a result, it is very difficult to present a varietal map by village. A number of general trends can be distilled from our observations, however. For example, in the case of aquatic rice, farmers usually transplant long cycle varieties on good fresh water fields and shorter cycle varieties on either salt-affected or drought prone fields. All varieties remain in nurseries for a considerable length of time (54 days on average), despite the farmer's preference to transplant early. This is because flooding is late each year, as compared to the pre-drought calendar. Varieties with cycles between 120 and 160 days are used primarily (Table 17). The cycle for phreatic (direct-seeded) rice varieties is usually 120 days or less. Higher yields are associated with varieties that have cycles between 90-105 days.

For those rice fields followed in 1984 and 1985, the proportion of the total area planted that was in improved varieties was 22% for phreatic rice

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[11]In certain villages, however, the range of varieties is not very large, as there are well-adapted varieties in use. Thus at Tendimane, 55% of the monitored plots were in "Senecoly," and at Boukitingo, 77% were transplanted with "Mpack," both local varieties. At Boulom and Boulandor, on the other hand, improved varieties predominated (144B/9 and IR-8).

TABLE 17

YIELD (KG/HA) AND AREA PLANTED (%) OF LOWLAND AREAS BY RICE VARIETY AND LENGTH OF CYCLE

A. Phreatic Rice

Cycle[a]	Yield (kg/ha) 1983	Yield (kg/ha) 1984	Yield (kg/ha) 1985	Area (%) 1983	Area (%) 1984	Area (%) 1985
Less than 91 days	933	1,250	1,256	14	25	13
91 to 105 days	730	1,107	1,610	26	38	42
106 to 119 days	710	1,114	1,285	23	20	30
120 to 133 days	1,015	966	1,222	14	8	8
More than 133 days	977	706	727	22	9	6

B. Aquatic Rice

Cycle[b]	Yield (kg/ha) 1983	Yield (kg/ha) 1984	Yield (kg/ha) 1985	Area (%) 1983	Area (%) 1984	Area (%) 1985
Less than 105 days	954	587	1,347	3	2	3
105 to 119 days	842	720	1,351	6	19	18
120 to 133 days	924	697	1,633	32	27	25
134 to 147 days	1,003	942	1,475	25	27	21
148 to 161 days	917	1,162	1,041	26	18	25
More than 161 days	681	693	643	9	5	8

[a]Phreatic rice: cycle from direct seeding to harvest.

[b]Aquatic rice: cycle from the planting in the nursery to harvest.

and 12% for aquatic rice.[12] As for the origin of the seed, in 1985 73% of the area planted was from personal stock, 7% was purchased, and 28% came from the extension agency (PIDAC) or the research station (ISRA).

The farmers' desire for short cycle varieties is being taken into account by the ISRA rice breeders. To date, more than 400 varieties are the object of an agronomic/morphological inventory. For the transitional rice zone, several short cycle varieties that are adapted to local conditions and resistant to rice blast are being evaluated (see Variety Trial-Transitional Rice Zone). For the aquatic zones which are not affected by salt intrusion, other adapted varieties are being tested. It is for areas where iron toxicity and salt intrusion are problems that the greatest amount of work remains to be done.

G. Fertilization

Application of organic matter is the traditional means of fertilizing the rice fields. Animals are corralled in certain areas and the manure collected and transported to the paddies. The situation in the Lower Casamance today, however, is characterized by lack of labor to transport manure and the inability of many farmers to purchase commercial fertilizer. Nevertheless, in the Department of Oussouye (Boukitingo, Loudia-Ouoloff, and Seleky), some women still bring organic fertilizer (manure and ashes) to the aquatic rice fields just before the rainy season. About a third of the better fields (20% of the total area) are fertilized in this manner each year.[13] The amount of organic matter that is applied varies between 2 and 7 tons/ha. As is shown in Table 18, the additions have a beneficial effect on yield in a wet year (1982 and 1984), while chemical fertilizer had no effect or even a negative one. Inorganic fertilizers are not typically used on the best aquatic

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[12]These figures must be interpreted cautiously as they are based on a relatively small sample--10 villages in 1984 (125 farms) and 9 in 1985 (35 farms).

[13]Organic fertilizer is generally reserved for the deeper rice fields where salt intrusion is not a problem (80% of the cases). These are usually the first fields to be transplanted (in 1984, three weeks before the non-fertilized plots). In some cases, organic matter (ash) is added to particularly acid soils where iron toxicity often is a major problem (Tendimane, Loudia-Ouoloff).

rice fields, however, and this explains why their effect on yield is negligible.

TABLE 18

FERTILIZER APPLICATION - AQUATIC RICE IN THE OUSSOUYE DEPARTMENT

Type of Fertilizer		1982	1983	1984
Organic[a]	Yield (kg/ha)	1,617	927	1,317
	% area studied	20	29	21
Inorganic	Yield (kg/ha)	--	783	785
	% area studied	0	15	7
	Amount (kg/ha)	--	107	63
None	Yield (kg/ha)	1,028	777	885
	% area studied	80	56	73
F-Test		6.2[b]	NS	4.61[b]

[a]Organic fertilizer is generally a mixture of animal manure and sand to which is added organic matter which has been burned.

[b]Significant at 1%

NS = Not Significant

For phreatic rice, the situation is different (Table 19). With the exception of 1982,[14] the use of organic fertilizer is not widespread. Chemical fertilizer is being used, however, and the response is better than it is for aquatic rice. Under the influence of the extension service, farmers

[14]At Tendimane and Boulandor, a third of the phreatic rice plots were fertilized organically in 1982. Since then, farmers have only spread organic matter on a few plots each year (about 10%).

TABLE 19

FERTILIZER APPLICATION - PHREATIC ZONES II, III, IV AND V

A. Basal Application

Type of Fertilizer		1982	1983	1984
Organic	Yield (kg/ha)	1,476	599	1,058
	% area studied	15	3	2
Inorganic	Yield (kg/ha)	1,428	1,122	1,310
	% area studied	5	1	33
	Amount (kg/ha)	50	--	117[a]
None	Yield (kg/ha)	895	557	646
	% area studied	80	96	65
F-Test		NC	NC	5.21[b]

B. Top Dressings

Type of Fertilizer		1982	1983	1984
Urea	Yield (kg/ha)		1,240	1,281
	% area studied	--	9	22
	Amount (kg/ha)		35	114[a]
None	Yield (kg/ha)		500	778
	% area studied	--	91	78
F-Test			7.4[b]	6.21[b]

[a]In 1984, at Boulom, the average was 200 kg/ha (8:18:27) of basal application and 100 kg/ha of urea top dressed. At Boulandor, the average was 200 kg/ha (8:18:27) of basal application and 100 kg/ha of urea. At Tendimane, the average was 50 kg/ha (8:18:27) of basal application and 35 kg/ha of urea

[b]Significant at 1%

NC = not calculated due to insufficient data

-- = not measured

have begun applying commercial fertilizers to their better rice fields. If in general farmers' yields with chemical fertilizer leave something to be desired when compared with station trials, they produce nonetheless almost twice that obtained on unfertilized fields. Spreading organic matter improves yields even more, just as it does on aquatic fields.

Data from the last two years of the study (1984 and 1985), indicate that basal applications of fertilizer results in an increase in paddy yield of 2.5 kg/ha for each kilo of NPK (8:18:27) utilized. Top dressing has an even greater effect. There is a rise of 3.5 kg/ha of paddy for every kilo of urea (46% N) used.[15]

The trials examining the effect of fertilizing direct-seeded rice show that on certain fields (very acidic and/or very sandy) there is no response to fertilizer, while on others, applications of only 100 kg/ha of 8:18:27 and 75 kg/ha of urea markedly improve yields (See Fertilizer Trials).

H. Date and Mode of Planting

A priori, the farmers of the Lower Casamance prefer transplanting to direct seeding because it gives them better returns to land and labor. The drought nevertheless has required them to begin changing their previously viable farming system, albeit cautiously.

1. Direct Seeding

Direct seeding is carried out either by row seeding or by broadcasting. While weeding is facilitated when seeding is in rows, it requires flat tilled fields and is more time consuming. In the "mandingized" Diola zones the task of planting falls on women, and although they already till their fields flat, dribbling the seeds in rows is an additional burden. In the traditional Diola areas where direct seeding is new, the first constraint is to get farmers to till their paddies flat since their major tool, the cayendo, is designed for ridge and furrow plowing.

In both areas, mechanization would facilitate row seeding. Already in the villages of Tendimane, Suel and Bandjikaki, where animal traction is occasionally used in the rice fields, the move toward direct seeding is

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[15]Results obtained from the regional development agency's (SOMIVAC/BEEP) program ("Quart d'hectare") concluded that returns to added fertilizer were 2.9 and 3.6 kg of paddy for one kilo basal or sidedressing applications of fertilizer, respectively.

accelerated. Similarly, the introduction of the donkey-drawn peanut seeder at Boulandor to row seed rice has lightened women's work considerably.[16]

Whether seeding is done in rows or by broadcasting, the amount of seed used varies between 70 and 100 kg/ha. With good emergence this results in approximately 200 plants/m^2. Unfortunately, because of drought stress, insect infestation and poor seed quality, the actual density observed after planting is often on the order of 75 to 100 plants/m^2 (37% of the plots studied in 1985).

Basically, planting commences only when the soil is wet. However, cumulative rainfall does not correlate well with the date of planting, as Table 20 reveals. For example, in 1982 at Boulom and Tendimane, a year when rice represented the greatest proportion of the area cultivated (60 and 40%, respectively), rice was planted very early, after 80 mm of rain had fallen. In the course of the next two years, as millet and maize took on greater importance in the cropping systems of these villages, men began postponing the preparation and seeding of the rice fields while they started their upland crops. In Maoua, Boulandor and Medieg, where transitional rice is in the hands of women, other factors intervened. At Maoua for example, after two years of early planting which did not bring about good results, in 1984 women got involved in a number of off-season activities in the hopes of generating some income (palm oil production, salt collection, and communal gardening). Thus they were unprepared when in 1984, 150 mm of rainfall had been received by June 15th. This also explains why they reverted to early planting the following year.

At Boulandor and Medieg, the earth is still hard in the beginning of the rainy season. Turning the soil requires a lot of time and for several years farmers have had to wait until at least 200 mm had fallen before they begin planting most rice fields.

The typical scenario for direct seeding is to begin in the higher fields with short cycle varieties, and then progress to the lower fields,[17] where longer cycle varieties are planted. This strategy is adopted for two reasons:

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[16]The evolution of phreatic rice plots which were row seeded during a three-year period was as follows: 1982: 10%; 1983: 17%; 1984: 41%.

[17]Fields situated in the stream bed itself are an exception. They must be planted early to avoid submerging the seedlings when the heavy rains begin.

TABLE 20

AVERAGE DATE OF PLANTING FOR PHREATIC RICE AND CUMULATIVE RAINFALL DATA (PLOTS STUDIED 1982-85)

	1982[a]		1983		1984		1985[b]	
	Mean Date of Planting	Rainfall Total(mm)	Mean Date of Planting	Rainfall Total(mm)	Mean Date of Planting	Rainfall Total(mm)	Mean Date of Planting	Rainfall Total(mm)
Mahamouda	-	-	24/07	274	17/07	367	NM	-
Boulom	07/07	66	27/07	274	14/07	426	NM	-
Maoua	07/07	94	18/06	73	05/07	347	21/06	28
Boulandor	21/07	299	27/07	219	27/06	248	21/07	220
Medieg	07/07	109	21/07	216	15/07	340	NM	-
Tendimane	07/07	106	09/07	203	16/07	346	08/08	503
Suel	NM	-	01/08	214	24/07	364	07/08	374
Mean	10/07	135	20/07	210	11/07	349	18/07	219

[a]Month of June was estimated

[b]Bandjikaki: 05/07--46 mm; Toukara: 12/07--135 mm; Seleky: 26/07--231 mm; Toukara: 12/07--135 mm; Seleky: 26/07--231 mm

NM Not Monitored

to get some return from the driest fields by planting them first, and to stagger the harvest. In fact, the upper rice fields, which are planted with early season varieties, are often ready for harvest a full month before the rice fields planted on the lowest fields.

2. Transplanting

Nurseries are prepared around the 20th of July. Farmers plant them at this time in order to have the seedlings ready toward the end of August. With this schedule, if the rains are abundant they can transplant as early as August 15, but if the rains are late, farmers can avoid having to transplant seedlings that are too old. Farmers surveyed indicated that the time of planting nurseries is as much as a month later now than during the 1960s when rainfall was adequate. In a dry year like 1983, more than half the rice fields were transplanted with seedlings that were more than seven weeks old (the average age was 7.8 weeks; see Table 21). To compensate for the reduction in tillering of these older plants, fields were transplanted with two or three seedlings per hill instead of only one.

TABLE 21

PERCENT OF TRANSPLANTED RICE FIELDS WITH PLANTS OF DIFFERENT AGES (1982-84)

	Number of weeks in the nursery		
Year	> 5 weeks	> 6 weeks	> 7 weeks
1982	72	52	25
1983	90	78	61
1984	58	44	27

The date of transplanting in the salt-affected fields is obviously a function of rainfall. In the fields observed where salt was a problem (38 in 1983 and 13 in 1984), transplanting did not take place until an average 890 mm was received. In fields where salt was not a problem, it is difficult to determine the date on the basis of rainfall (see Table 22). In a dry year like 1983, the farmers transplanted in mid-September, hoping that the last rains in September would fill the paddies. In 1984, good rains in June and July got ahead of the farmers and they had to wait for the plants in the seedbeds to grow before transplanting could be tackled. A different scenario was observed in 1985 which had good rainfall in September, thus permitting transplanting to continue through the end of October. Despite these yearly differences, in general transplanting occurs after 750 mm of rain has fallen towards the 10th of September in valleys that have no dams. In Boulom, which is up-river from the Guidel dam, transplanting took place about two weeks earlier.

Transplanting on ridges is done in 4 to 6 rows per ridge with a 10 to 15 cm separation between the hills. The resulting density is approximately 30 to 40 hills/m2. At that density, the hills are rather crowded on the top of the ridges, which are only between 50 and 80 cm wide. Flat plots are generally transplanted with uniform spacings of 15 by 15 to 25 by 25 cm.

The inverse of what is done in the transitional zones occurs in the aquatic zones. The lower fields are transplanted first. Ridging and transplanting must occur early in aquatic fields because these tasks are extremely difficult when the field is deeply flooded. Farmers work up the toposequence progressively and then return to the rice fields in the salt affected areas.

The correlations between date of planting or transplanting and yield are significant (.05).[18] Linear regression indicates that a delay of one week in the date of planting/transplanting results in yields lowered by approximately 55 kg/ha (Table 23).

3. Labor Time

Preparation of the nursery, transporting and transplanting seedlings take an average 50 person-days/ha. Direct seeding by broadcasting is more rapid and takes only 10 person days/ha. Manual direct seeding in rows takes a little longer (between 12 and 19 person days/ha) due to the difficulty of trickling the seed in rows. In trials with the Super Eco seeder, a team of two men and a pair of oxen were able to seed a hectare in 3.5 days.

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[18]Results from SOMIVAC's "Quarter Hectare" project (SOMIVAC, 1985) shows that in 1984, for every week planting was delayed after June 15th, yields for direct-seeded rice were lowered by 130 kg/ha.

TABLE 22

AVERAGE DATE OF TRANSPLANTING FOR AQUATIC RICE AND CUMULATIVE RAINFALL (1982-85)

	1982[a]		1983		1984		1985[b]	
	Mean Date of Planting	Rainfall Total(mm)	Mean Date of Planting	Rainfall Total(mm)	Mean Date of Planting	Rainfall Total(mm)	Mean Date of Planting	Rainfall Total(mm)
Boukitingo	15/09	815	18/09	844	22/08	742	26/09	938
Loudia	10/09	780	09/09	689	01/09	799	23/09	844
Mahamouda	07/09	698	09/09	455	25/08	780	NM	-
Seleky	NM	-	NM	-	NM	-	27/09	1,206
Boulom	22/08	429	09/09	478	19/08	762	NM	-
Maoua	12/09	781	12/09	613	01/09	888	14/09	1,027
Medieg	08/09	734	18/09	437	28/08	598	NM	-
Gandjikaki	05/09	772	06/09	680	09/09	544	30/09	1,147
Boulandor	10/09	825	-	-	07/09	861	05/09	904
Average	07/09	729	12/09	599	30/08	746	20/09	1,010

[a] Months of May and June were estimated

[b] Tendimane: 16/09; 1,002 mm

NM = Not monitored

TABLE 23

REGRESSION COEFFICIENT (a_1): EFFECT OF DATE OF PLANTING OR TRANSPLANTING ON YIELD (ALL VILLAGES)

$Y = a_0 + a_1X$	1983	1984	Mean a_1
Phreatic Rice	-22[a]	-87[a]	-54
Aquatic Rice	-62[b]	-54[b]	-58

[a]Significant at 5%

[b]Significant at 1%

X = Week of planting

Y = kg/ha

I. Weeding

The lowland areas unaffected by salt are heavily infested with weeds. Their control is essential for good rice yields. Thus women till twice before transplanting in the "mandinguized" Diola areas, and, in zones where the cayendo is employed, the laborious task of making ridges and incorporating the weeds takes place. If at the time of transplanting the plot is clean, subsequent weeding is not usually necessary (see Table 24).

In the higher rice fields which are direct-seeded, one weeding is necessary even if land preparation is well done. Weeding is difficult and time-consuming work, especially when the plots are broadcast seeded (50 person days/ha). When this method is used, women often make several passes through the field to hand pull weeds. Regression analysis on data collected in 1984, a wet year, shows that for each week after planting that weeding is delayed (beyond two weeks), the average yield of paddy is lowered by 80 kg/ha.[19]

TABLE 24

PERCENT OF WEEDED FIELDS - LOWLAND AREAS

	Year	% Plots Weeded	Interval Between Planting & Weeding (days)
Phreatic Rice	1982	79	43
	1983	66	40
	1984	81	31
Aquatic Rice	1982	2	NC
	1983	5	NC
	1984	18	NC

NC = Not calculated

Two proposals emerge from our research which address the weed problem. First is the use of herbicides which has just begun to interest Casamance farmers. In the herbicide trials (see Herbicide Trials), treated plots took much less time to weed than untreated plots. Also the survey data from 1984 showed a yield advantage to using herbicide. [Plots without herbicide yielded 803 kg/ha (n=239); those with herbicide had yields of 1,276 kg/ha (n=71).] A second option for farmers is to use seeders (see Tests with Animal Seeders). This method permits row seeding which in turn facilitates hoe weeding. Seeders are already being used in Boulandor and were tested for the first time in Bandjikaki in 1985.

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[19]On-station trials show an even greater effect of weeds in transitional zones. In 1983, a dry year, plots left unweeded for five weeks after planting produced 47% less than the control. In a wet year (1984), late-weeded plots produced 17% less than the control (ISRA, 1985c).

J. Bird Scaring and Harvesting

Protecting the fields from predators and birds is something which is more important in some areas (the south) than in others. It becomes more important, the earlier the planting. The birds are attracted to the first grain crops ready for harvest. The range in time spent bird scaring was from 15-20 days/ha to as much as 80 days/ha.

As concerns harvesting, the minimum time required is 40 person days/ha. The great difficulty in measuring harvest time is that the work is staggered as different fields mature at different times and because labor is not always available when needed. Roughly speaking, a woman using a knife harvests approximately 25 kg/day of paddy.

K. Productivity

In this section, yields for lowland rice production are presented for the three categories of rice-producing villages discussed previously (see section IIA). The relation between yield per hectare and total labor time is an indication of returns to labor, a very important productivity criterion for traditional farmers. A summary of the labor data for various tasks follows.

1. Yield

Overall, rice yields were quite low during the four years of study. Table 25 shows that in villages with systems based on transplanted rice (Group I), yields approach 900 kg/ha (the average was 865), with the exception of Mahamouda.[20]

Villages in the second group (II) that direct seed and occasionally transplant rice produce yields that are higher on average, between 1,000 and 1,500 kg/ha. The extremely low yields in the two villages located in the northernmost part of the study area (Suel and Toukara) indicate that even direct seeding rice does not give adequate yields in marginal areas where soils are sandy and rainfall severely limits production.

Group III villages, located primarily to the east of Ziguinchor, are those which encompass several ethnic groups. Recall that farms operated by

[20] Mahamouda is a newly founded village of Malian immigrants who do not have access to good rice fields but who transplant rice every year in the hopes of a better harvest.

TABLE 25

AVERAGE YIELD (KG/HA) OF PADDY IN LOWLAND AREAS BY RICE PRODUCTION SITUATION

GROUP I[a]		Group II[b]		Group III[c]	
Village	Mean Yield (kg/ha)	Village	Mean Yield (kg/ha)	Village	Mean Yield (kg/ha)
Loudia-Ouol.	776	Tendimane	1037	Boulom	1281
Boukitingo	927	Boulandor	1211	Maoua	433
Seleky	892	Medieg	1554		
Mahamouda	235	Toukara	646		
		Bandjikaki	1339		
		Suel	230		

[a]Group I - Villages where transplanted rice is predominant - southwest region of Lower Casamance.

[b]Group II - Villages primarily based on direct-seeded rice.

[c]Group III - Mixed villages in which certain compounds transplant and others direct seed.

members of different ethnic groups are organized differently. Thus, for example, in Maoua the drought has required Mandinka women to direct seed in the valley on land that has very high levels of organic matter (15%). These soils are extremely acid and the yields obtained in recent years were almost as poor as in the salt affected fields. In the salt affected fields, women from another ethnic group (Diola) have been trying to transplant rice. To underline the variance seen between villages within categories, consider Boulom, where on less acid soils which are situated above an anti-salt dam, yields were much higher (above one ton/ha) for both transplanted and direct-seeded rice.

Despite relatively low average yields compared with its potential in tropical zones, lowland rice in the region of Ziguinchor has yielded better than upland cereals.[21] Lowland rice plots are somewhat less affected by climatic hazards than are plateau crops, thanks to their position in the toposequence.

2. Labor Time and Returns to Labor

From the preparation of plots to the harvesting of rice, the variation in time taken for different tasks is a function of the different cultural practices adopted. Table 26 summarizes the main activities and compares the demands for labor of each cultural practice.

Considering the size of the standard deviations of each operation, the total labor time per hectare for the different rice production systems are fairly similar. One notable exception is the use of roto-tillers which considerably reduce the demand for labor. The table also shows that across the two systems of rice cultivation (aquatic vs. transitional), land preparation with the cayendo is a little more rapid than with the fanting.

Since the total labor time per hectare is similar across systems, returns to labor is primarily a function of yield. When the rice fields are relatively unaffected by salt as is the case in Boulom and Medieg, returns to labor tend to be higher (more than 8 kg of paddy/person-day), in spite of high labor demands. It is the low yields (865 kg/ha) obtained in villages oriented toward transplanted rice (Group I) that explain why the return to labor is so low (5.9 kg/person day), even though the total demand for labor (146 person days) is not as high as it is elsewhere. In sum, although labor inputs are high, "innate" field productivity appears to be the factor that is the primary determinant of yield and consequently, returns to labor.

Nevertheless, average return to labor for lowland rice, 7.3 kg/person-day (land preparation by roto-tillers excluded), proves to be superior to that of upland cereals cultivated manually (maize: 6.4 kg/person-day; millet: 5.4 kg/person-day). However, it is not as high as the returns of maize cultivated by means of animal traction, which is near 10 kg/person day.

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[21]The agronomic survey estimated average yields during the same period (1982-85): maize: 818 kg/ha; millet: 597 kg/ha; sorghum: 529 kg/ha; upland rice: 600 kg/ha).

TABLE 26

LABOR TIME (A) AND RETURNS TO LABOR (B) FOR LOWLAND RICE PRODUCTION[a]

A. Labor Time[b]

	Transplanted Rice			Direct Seeded Rice		
	Tillage with a "cayendo"	Tillage with a "fanting"[c]	Mechanized Tillage	Row Planting "fanting"	Broadcast Planting "fanting"	Ridge Planting "cayendo"
Clearing	14 (16)	12 (15)	12	12	11 (7)	12
Tillage	41 (24)	46 (30)	10	42	42 (26)	30
Planting	-	-	-	12 (7)	9 (12)	12
Transpl.[d]	47 (27)	56 (20)	44 (17)	-	-	-
Weeding	2 (3)	10 (11)	4 (6)	52 (27)	75	52
Harvest	42 (37)	51 (34)	47 (32)	48 (28)	48 (22)	48
Total (Days)	146	175	117	167	185	154

B. Returns to Labor (kg/day)

Villages[e]	Loudia-O. Boukiti. Seleky	Medieg Boulom	Boulom	Boulandor Boulom	Medieg	Tendimane Suel
Group Category	I	II,III	III	II,III	II	II
Yield (kg/ha)	865	1418	1281	1246	1554	1037
Returns to Labor (kg/day)	5.9	8.1	10.9	7.5	8.4	6.7

[a]Results of surveys on resource use (inputs/outputs) at the plot level: 1983 (77 plots), 1984 (66 plots).

[b]In person-days, 8 hours per day. Figures in parentheses are standard deviations.

[c]Tilling with the "fanting" (long handled hoe) includes pulling up weeds and breaking up clods of soil.

[d]Labor time does not include tasks carried out in preparing the nursery.

[e]The villages used in returns to labor calculations are those in which soil problems did not constrain rice production (ie., non-salt affected fields).

L. Summary

1. Review of the Objectives of the Study

The multi-season agronomic survey of ten villages had three main objectives:

1) To describe the range of farming systems practiced by Casamance farmers, particularly with respect to rice cultivation.

2) To establish a detailed record of the productivity of the current rice cropping systems being practiced in the area.

3) To identify the most effective practices currently used by farmers, a first step in the formulation of extension recommendations designed to increase the productivity of these systems.

The approach adopted at the outset proved to be particularly useful for the first two objectives. The data base actually consisted of information collected in 13 valleys that were being monitored in the Lower Casamance. With respect to the 10 villages studied during the entire four-year period, rice farming strategies were identified. The villages in the Oussouye zone are still based on transplanted rice and their margin for expansion is limited by the abundance of rain which occasionally permits them to cultivate additional higher or salt-affected fields. For the villages that are beginning to adopt direct seeding, the number of options is greater. As soon as the first rains fall, direct seeding is initiated. If the year is a good one, transplanting of deep flooded fields can still take place in September. The situation is rather difficult for the villages in which work is organized according to the traditional Diola system (zones I, II and V) where men are responsible for preparing all the fields across the toposequence. At Tendimane for example, men divide their time between millet and groundnuts on the plateau, and direct-seeded rice in the lowland areas. In contrast, at Suel, on less productive rice fields, men first devote their energies to planting groundnuts and millet and do not till the rice fields until the end of July. By that point, they have little hope of obtaining good yields.

2. Analysis of Cultural Practices

The third goal of the study (identification of the most effective agronomic practices) proved to be particularly difficult to achieve given the current climatic situation. Fifteen years of drought have produced problems for which farmers are only beginning to find solutions. Shallow flooded rice fields, now phreatic, can only be direct-seeded. Higher fields are planted in sweet potatoes or cowpeas or abandoned altogether. Other fields often do not desalinate sufficiently during the rainy season.

In zones situated further up-river (zones II, III, and IV), people are forced to direct seed, but in many valleys the results are mediocre. At Suel where the rice fields are situated at the entrance to a very sandy valley and receive very little run-on, yields rarely exceed 500 kg/ha. It is not surprising that the only productive rice fields are those which border the active stream beds.

Further to the south in the Blouf, the villages of Tendimane and Mahamouda are both situated along the bolongs. In these flood plains, which were formerly used for transplanted rice, farmers have begun direct seeding, but in this case too, the results have not been good. The fields are sandy, acid (pH < 4.5), very low in available phosphorus and subject to iron toxicity. Similarly, in the Maoua valley, the transition from transplanted to direct-seeded rice is difficult. Soils there are also high in organic matter and deficient in phosphorus as well as being acid. It is our hypothesis that organic acids in the soil significantly constrain rice production. Thus it is not surprising that in valleys where soil chemistry is the predominant problem, there is little correlation between agronomic practices and yield.

In aquatic rice zones too, the drought has had both direct (water stress) and indirect effects [early salt reentry; reinforcing iron toxicity (see Appendix 5)]. As observed in Table 25, average yields of transplanted rice (Group I) are as low as those registered in some other areas recently converted to direct seeding (Groups II and III).

Because of the heterogeneity of the environment, the results of the survey itself must be analyzed with caution. A good comparison of different practices was nearly impossible to find since rarely were they applied to the exact same type of field, as would have been the case in a classical agronomic experiment. For example, flat tillage is practiced in some of the study villages (Boulom, Maoua, Boulandor, Medieg, and Toukara) and ridge and furrow tillage is done in others (Suel, Tendimane, Bandjikaki, Mahamouda, Boukitingo and Loudia-Ouoloff). This locational specificity makes the interpretation of survey data hazardous. Also, certain variables are often difficult to quantify or were not analyzed at a detailed enough level. For example, weed control is represented by the time interval between planting and weeding, while the quality of weeding is not accounted for. Moreover, for the surveys, the onset and duration of activities were registered and analyzed in terms of weeks instead of days (1982 - 1984), sometimes with the result that an interval of 13 days versus 4 days appeared to be the difference of a single week. In order to minimize the effect of environmental variability, we decided to analyze only those valleys where natural constraints were somewhat less severe. Within these valleys we focussed on "productive" and "less productive" fields. Our objective was to identify farmers' interventions that would result in yield increases.

Table 27A presents data from three valleys in which phreatic rice is grown. In general, the results show that rice fields planted early (one week ahead of average) and weeded early (one week ahead of average) produce the best yields. At Boulom and Boulandor in 1984, there was also a significant effect observed for fertilizer application. As mentioned earlier, yield is correlated to the position in the toposequence. More than two-thirds of the "productive fields" are found in intermediate or lowland areas. As concerns the length of the rice cycle, the pattern is not very clear. In 1984, the most productive plots were seeded with short cycle varieties in Boulandor and Boulom, but in 1983, it was otherwise in all three villages.

For aquatic rice, the differences in yield were very large (Table 27B). The number of weeks of flooding was the major factor contributing to the variation. The management of the farm affects aquatic rice less than transitional rice. Apart from the date of transplanting (which depends on the water level) there are few interventions a farmer can adopt that will significantly improve yields since weeding is rarely done and fertilizers are not applied. The apparent absolute dependence of yield on rainfall and location of the field complicates an analysis of farming practices for aquatic rice.

3. Observations at the Farm Level

It is surprising to note that at the farm level, plots can be found which are good one year and poor the next. There are several reasons for this. First, there are natural factors. For example, a good plot in a wet year may not be the best plot in a dry year. Second, cultural practices are not always consistent from year to year. Occasionally farmers add organic or inorganic fertilizer to some fields. Lastly, random factors like poor germination, insects and weed infestation play a part. Women examine the

TABLE 27
COMPARISON OF AGRONOMIC PRACTICES ON HIGH YIELDING AND LOW YIELDING PHREATIC (A) AND AQUATIC (B) RICE FIELDS

A. Phreatic Rice

	Villages											
	Boulandor				Boulom				Medieg[a]			
	1983		1984		1983		1984		1983		1984	
Yield Category (kg/ha)	1-499	>1500	1-499	>1500	1-499	>1500	1-499	>1500	501-999	>1500	501-999	>1500
Mean Yield (kg/ha)	198	2089	268	2056	390	1934	284	2045	787	2041	801	1785
% Area	26	7	21	39	11	23	23	30	19	23	14	25
Week of Planting	29.8	28.6	26.2	25.8	29.7	30.7	27.4	27.7	29.1	28.9	29.2	28.2
Interval between Planting/Weeding (wks)	5.1	5.6	4.2	3.6	3.3	3.0	3.4	3.0	6.4	6.1	6.6	5.4
Basal Chemical Fertiliz. (kg/ha)	-	-	12	11	-	-	42	165	-	-	0	0
Top Dressed Chemical Fertiliz. (kg/ha)	15	16	0	40	58	43	64	140	0	0	0	0
Variety-Length of Cycle (wks)	14.4	16.4	16.1	14.9	12	14.0	15.5	13.7	14.0	18.0	16.8	16.8
Level of Field in Toposequence (% frequency)												
High			42	30			33	20			60	5
Intermediate			21	48			58	64			33	65
Low			26	21			8	16			6	30

[a]At Medieg, as there were few fields producing <500 kg/ha, a 501-999 kg/ha yield category was employed.

B. Aquatic Rice

	Year					
	1983[a]		1984[a]		1985[b]	
Yield Category (kg/ha)	1-499	>1500	1-499	>1500	1-499	>1500
Mean Yield (kg/ha)	269	1967	280	2004	335	2256
% Area	29	16	11	8	11	22
Week Transplanted	37.1	36.1	28.8	27.9	39.7	37.9
Length of Stay in Nursery (days)	57	50	50	53	57	41
Length of Time in the Field (days)	91	92	87	92	93	86
Weeks of Flooding	3.2	5.7	4.5	9.5	5.2	7.5

[a]Average - Loudia Ouoloff and Boukitingo
[b]Average - Loudia-Ouoloff, Boukitingo and Selekynn

fields after emergence and have a tendancy to invest their time on the most promising areas. Indeed, most often, the order with which plots were weeded corresponds to the level of yield for any given farm.

Table 28A presents the weighted average yield (kg/ha) for all plots of each farm by year. This performance measure allows a comparison across farms with different labor availability as well as across years with different rainfall patterns (which affects the area planted). At the same time, this measure squarely places the emphasis on the farmer's primary objective which is to maximize total rice production. The weighted yield index was chosen instead of returns to labor per farm worker because sufficient labor time was not available.

In the three valleys where transitional rice is dominant, several observations will clarify the situation further:

1) The plots were relatively productive in 1982, particularly at Medieg. About a third of the fields at Medieg and half the fields at Boulom were planted in aquatic rice, a strategy that allows farmers to take advantage of the entire toposequence of the lowlands.

2) In 1983, a dry year, production fell, especially at Boulandor. In this village, the lowest fields had high salt concentrations and consequently only the more marginal upper fields were cultivated. In contrast, at Medieg, certain fields along the stream bottom were direct-seeded for the first time, permitting some level of production. At Boulom, thanks to the Guidel anti-salt dam, phreatic rice maintained average yields.

3) In 1984, yields climbed at Boulandor particularly and aquatic rice once again gained favor in the Boulom and Medieg valleys.

4) Of particular interest is the fact that for any given village during any given year, weighted yields have a tendancy to cluster around their mean (Table 29). The very low values can be explained by the lack of labor available to particular farming units,[22] while values which are on the high end of the continuum can be attributed to the use of more productive farming techniques such as roto-tillers, fertilizers or herbicides. The variation here

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[22]There are several examples. Medieg: in 1983 and 1984 at two different farms, the young women in the family who work as domestics in Dakar during part of the year returned to the village late in the season. Boulandor: in 1984, at one farm a women divorced her husband during the cropping season and left the village.

TABLE 28

WEIGHTED YIELD (kg/ha) BY COMPOUND FOR PHREATIC (A) AND AQUATIC RICE (B)

A. Valleys with predominantly phreatic rice - weighted yield (kg/ha)

Boulom				Medieg				Boulandor			
Compound	1982	1983	1984	Compound	1982	1983	1984	Compound	1982	1983	1984
1	1402	1143	1189	1	2183	1454	844	1	2162	278	1774
2	2425	903	1171	2	2788	1335	1309	2	2628	855	1475
3	2713	1337	1175	3	3380	589	1181	3	1739	33	1481
4	1462	1137	1270	4	3426	1198	1458	4	973	164	1021
5	609	883	883	5	2909	1474	1392	5	1724	196	713
6	1107	1104	885	6	2753	1519	1539	6	1042	23	505
7	1189	925	1106	7	2307	660	1368	7	2562	480	1487
8	1839	1396	1653	8	2841	1125	1270				
9	1437	690	1391	9	-	1038	1262				
10	2668	703	1990	10	-	1445	1226				
Mean	1685	1022	1266	Mean	2823	1183	1284	Mean	1832	290	1208

TABLE 28 continued

WEIGHTED YIELD (kg/ha) BY COMPOUND FOR PHREATIC (A) AQUATIC RICE (B)

B. Valleys with primarily aquatic rice - weighted yield (kg/ha)

Loudia-Ouoloff				Boukitingo			
Compound	1982	1983	1984	Compound	1982	1983	1984
1	1144	1376	400	1	620	412	802
2	234	27	252	2	1852	1583	1550
3	728	507	252	3	544	938	645
4.1-4.3	1166	883	833	4	991	647	1097
5	1448	683	1082	5	1244	1277	1085
6	0	241	481	6	1049	1414	910
7	419	130	809	7	1669	1948	1560
8	719	599	386				
9	217	493	616				
10	878	316	1469				
Mean	695	525	653	Mean	1138	1174	1093

TABLE 29

COMPOUND WEIGHTED AVERAGE YIELD COMPARED TO THE VALLEY MEAN[a] RESULTS OF FIVE VALLEYS IN LOWER CASAMANCE.

A. Valleys where phreatic rice predominates--yield frequencies

	Number of Compounds										
	Boulom				Medieg				Boulandor[b]		
	1982	1983	1984	Total	1982	1983	1984	Total	1982	1984	Total
Yield Category:											
1. <X - 20%	3	2	2	7	1	2	1	4	2	2	4
2. >X-20%, <X+20%	4	6	6	16	6	4	9	19	3	4	7
3. >X + 20%	3	2	2	7	1	4	0	5	2	1	3

B. Valleys where aquatic rice predominates--yield frequencies

	Number of Compounds							
	Loudia-Ouoloff				Boukitingo			
	1982	1983	1984	Total	1982	1983	1984	Total
Yield Category:								
1. <X - 20%	4	4	5	13	2	3	2	7
2. >X-20%, <X+20%	2	3	1	6	3	1	3	7
3. >X + 20%	4	3	4	11	2	3	2	7

[a]X = average weighted yield for each valley by year.

[b]1983 data at Boulandor not included due to numerous failed rice fields.

illustrates the positive response of indigenous farming systems to improved inputs.

In contrast, in two valleys where transplanted rice predominates, the analysis of weighted yields by farm unit did not reveal such clear trends. First, as can be seen in Table 28B, there is less variation in yield across years. This is attributed to the fact that only the fields that are flooded and not affected by salt are transplanted at all. Generally speaking, it is primarily the area transplanted rather than yield which is a function of rainfall. Moreover, aquatic rice yields cluster less about their means (Table 29B) than transitional rice. As discussed in the analysis of farming practices, the only factor that can explain the variation in yield is the length of time the field is submerged. Farms which have early flooded rice fields usually obtain relatively good yields. There are others, however, where the fields are not as productive because of iron toxicity, salt intrusion and water stress. For these fields, no simple farmer intervention can improve yields.

In conclusion, direct seeding rice allows for far greater human intervention at the field level. In each valley where direct seeding predominates, the farms with the highest yields were those that had adopted improved farming practices such as fertilizer applications or early mechanical seeding. Farms at the low end of the production continuum generally faced a shortage of farm labor. In the case of transplanted rice, however, our results show that little can be done at the farm level. Before agricultural intensification can occur on individual farms, the water problems of the entire valley must be addressed. This can only be accomplished by relatively large scale interventions such as the construction of anti-salt or fresh water retention dikes.

PART TWO:
AGRONOMIC TRIALS

Concomitant with the survey work discussed in Part I of this paper, the Farming Systems team conducted a series of agronomic experiments.[23] These trials were carried out both on the station (25%) and on farmers' fields (75%). The first research theme concerned the intensification of rice culture in lowland areas which have an adequate supply of water. This objective was studied in a number of ways: by using improved rice varieties in these areas (Trials I and II); by utilizing fertilizer (Trial III); and by better controlling weed growth (Trials IV and V). The second theme was inspired by the the current drought. To study the impact of the rainfall deficit, we focussed on the most efficient use of different sites in the toposequence. Thus, we compared transplanted and direct-seeded rice in the transitional zone (Trial VI), and the decision to grow rice versus maize in the upper slopes (Trial VII). In the most humid areas, an attempt to cultivate sweet potatoes after rice was examined (Trial VIII).

[23] A number of themes were studied in collaboration with the the Rice team and the Watershed Development team. The interpretation and conclusions of the work reported here, however, are those of the Farming Systems team alone.

III. VARIETAL TRIALS--TRANSITIONAL RICE ZONE

A. Introduction

The object of the trials was to study and evaluate several improved phreatic rice varieties.[24] The varieties used had already been tested on the station and in multilocational trials carried out by the Rice team. The idea was to see if a number of varieties which were in the last stages of selection passed farmers' scrutiny.

B. Experimental Design

The study was carried out in two ways: as a variety trial with two repetitions; and as a field-size comparison between one improved variety, selected on the basis of the initial varietal trial, and one local variety. In the case of the former, plots were 30 m^2 (except in 1982 when the plots were 15 m^2) and comprised of 10 rows of each variety that were 10 meters long (seeded at 70 kg/ha). The field-size comparisons consisted of two plots 300-500 m^2 each. One plot was planted with the improved variety chosen by the farmer and the other with her local variety. The two plots were managed under local agronomic practices.

The variety trial plots received basal phosphate dressing (400 kg/ha of Taiba rock phosphate) and 100 kg/ha of 8:18:27 (except in 1982 when 100 kg/ha of 10:10:20 was applied).[25] For the field-size tests, fertilizers were not applied in 1983 and 1984. In the third year, however, 25% of the recommended dose was used, namely, 50 kg/ha of 8:18:27 and 37.5 kg/ha of urea. This was done to give the improved varieties a better chance of expressing their yield potential.

Five varieties were studied: DJ-12-519, IRAT 112, IRAT 133, IKP and 144B/9. All of these are relatively short cycle varieties (90-105 days), which are about a meter tall, and have good tillering capacity (235 panicles/m2) (see Table 30). Yields for these varieties on-station had been in the order of 3.7 tons/ha of paddy.

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[24]These trials were conducted with the Rice team of the Djibelor Research Station.

[25]Basal fertilizer applications were small and had the objective of homogenizing the plot area, rather than markedly increasing yields.

TABLE 30

CHARACTERISTICS OF IMPROVED VARIETIES FROM THE VARIETAL TRIALS (VT) AND ON-STATION STANDARDS (S) FOR TRANSITIONAL ZONE RICE

Variety	Cycle (days)		Height (cm)		Panicles/m^2		Yield (kg/ha)	
	S	VT	S	VT	S	VT	S	VT
DJ-12-519	105	108	96	77	239	198	4000	2564
IRAT 112	91	97	105	81	207	166	3000	1549
IRAT 133	95	105	102	80	219	160	3500	2078
IKP	110	110	85	78	248	239	4000	2589
144B/9	100	97	100	74	214	171	3000	1730
Mean	100	103	98	78	235	187	3700	2102

C. Results

Only 13 of the twenty varietal trials conducted lent themselves to statistical analysis. Three of the original 20 were situated in sandy, elevated fields (in the Oussouye zone) which were once used for transplanted rice but had been abandoned for over twelve years. The trials in this setting did not produce at all, which suggests that without a considerable investment direct-seeded rice should not be recommended there. Four other trials yielded virtually nothing in 1983, which was a particularly dry year. Among the trials that were harvested, there was a significant difference between the varieties in eight cases. In seven of the eight, the improved variety, DJ-12-519, was superior to the local variety as Table 31 indicates.

The average yields at the 13 sites which were analyzed were relatively high but were nevertheless far from reaching their potential. In general, as can be seen in Table 30, improved varieties were shorter statured in the on-farm trials than when grown on station (by 20%). They also show a reduction in tillering of 20%. Yields for the trial represent only 60% of the standard. I Kong Pao (IKP) was arithmetically the highest yielding, but its

TABLE 31
TRANSITIONAL ZONE RICE-YIELDS (KG/HA) FOR VARIETY TRIALS 1982-85

Zones	Niaguis			Kalounayes						Fogny-Combo			Djibelor	Mean
Villages	Maoua			Boulandor			Medieg			Bandjikaki/Suel			Station	of 13
Year	1982	1983	1984	1982	1983	1984	1982	1983	1984	1984	1985	1984	1984	sites
DJ-12-519	1383	1750	767	3466	3366	4433	2366	3883	4017	1500	1250	1111	4039	2564
IRAT 112	-	616	317	1700	433	3766	-	2055	2183	1126	1750	740	2357	1549
IRAT 133	-	1067	908	2233	3000	3366	2171	2883	3100	1750	1250	842	2363	2078
IKP	1633	1408	1017	2933	2633	4516	2900	3533	4833	2034	2250	1379	PS	2589
144B/9	NP	NP	725	NP	NP	3450	NP	NP	3266	1250	750	611	2060	1730
Local	1766	1350	433	2200	2600	2516	2200	3083	2916	1750	2416	1425	2892	2119
Mean	1594	1238	695	2506	2406	3675	2409	3087	3386	1568	1611	1018	2742	2105
F-Test	NS	NS	14.3 (b)	9.3 (a)	24.5 (b)	21.7 (b)	NS	24.4 (b)	6.9 (a)	NS	5.1 (a)	NS	12.6 (a)	
CV %	22	26	14	12	14	6	26	6	15	30	25	28	11	
LSD .05 (kg/ha)	-	-	256	868	842	582	-	512	1342	-	1043	-	802	

[a]Significant at 5%
[b]Significant at 1%
- Variety not harvested (bird damage)
NP Variety not planted in the trial
NS Not Significant
Trials had 2 repetitions of 30m^2; 400 kg/ha of Taiba phosphate and 100 kg/ha of 8:18:27 applied at planting.

susceptibility to blast makes it a risky option for farmers. The three varieties developed in Côte d'Ivoire, (144B/9, IRAT 112 and IRAT 133) are of particular interest because of their short cycle (90-100 days), tolerance to blast, and resistance to lodging. Only IRAT 133 yielded as much as the local varieties, however.

An analysis by site and by year provides further information concerning the particular problems of growing rice in Lower Casamance. In fields with extremely acid soils such as those in Maoua, yields were not very good regardless of the variety. In 1984, two successive attacks of army worms contributed to the decrease in yield. Termites were also a problem. They usually invade sandy fields before flooding occurs. In a slow-starting year, the emergence vigor of a local variety like Barafita is an important feature in fulfilling yield potential. This was the case at Suel and Bandjikaki in 1985. In a wet year, on the other hand, this characteristic is less important (Djibelor station, 1984).

When the data of the three sites (Maoua, Boulandor and Medieg) are pooled over years, the findings observed for each separately are confirmed. The pooled analysis shows significant differences, attributable to the separate effects of year, site and variety.[26] The site by year interaction (Figure 5a) and the variety by year interaction (Figure 5b) were due to the problems discussed above (caterpillars, poor emergence and bird damage). The

[26]Analysis of variance for the combined analysis resulted in the following ANOVA table:

Source	df	F	Prob.
Site (S)	2	173.9	.000
Year (Y)	2	11.2	.000
S x Y	4	30.0	.000
Block (S x Y)	9	3.4	.006
Variety (V)	4	30.3	.000
S x V	8	4.3	.001
Y x V	8	4.4	.001
S x Y x V	16	2.1	.036
Error	29		

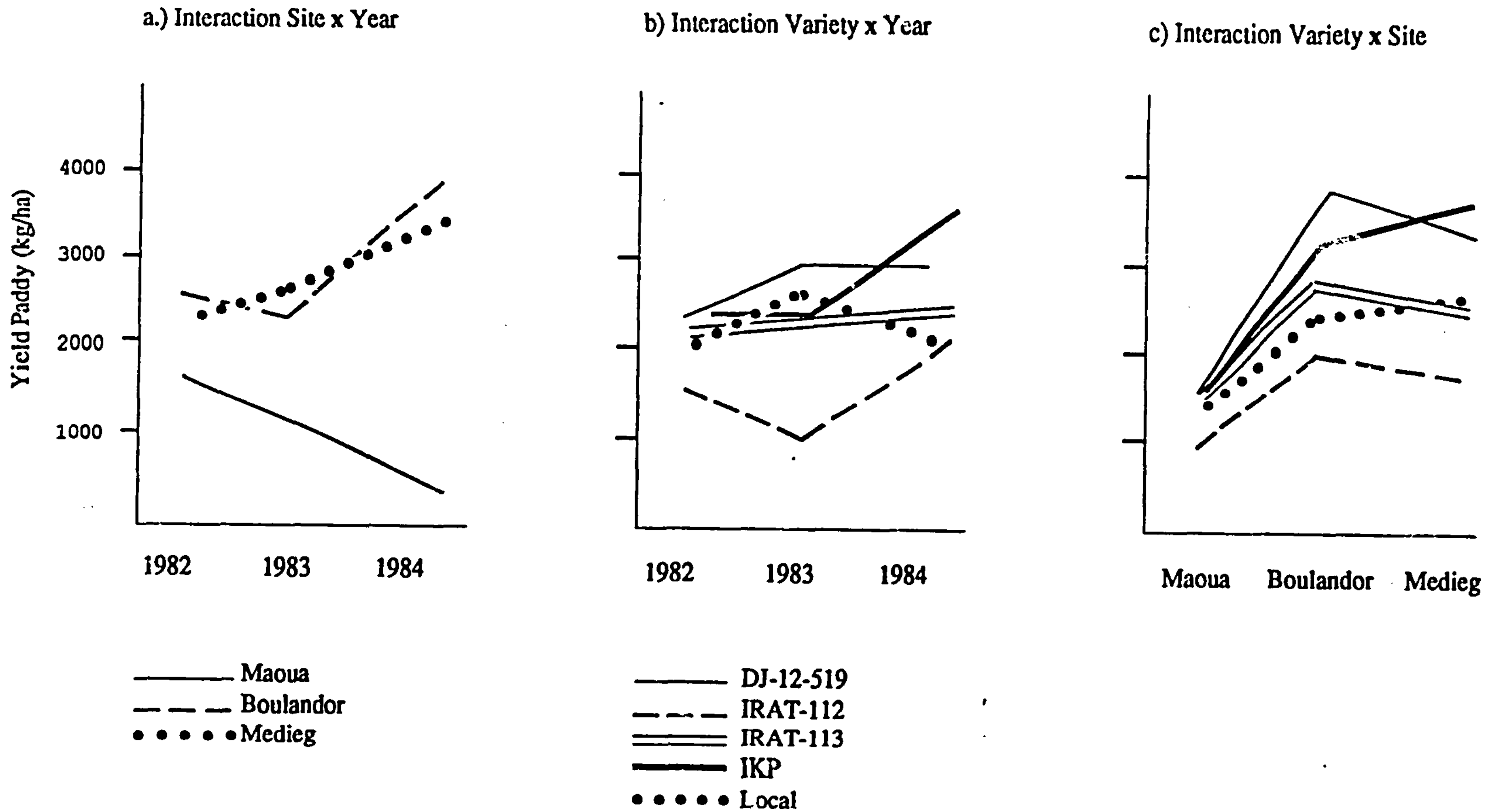

Figure 5

INTERACTIONS IN THE COMBINED ANALYSIS OF VARIETAL TRAILS

FOR TRANSITIONAL ZONE RICE

variety by site effect (Figure 5c) was also significant as no variety produced at Maoua and all five did well at Boulandor and Medieg. IKP and DJ-12-519 responded well in the best fields.

The field-size experiments reinforce the results of the varietal trials. Over a three-year period, 84 comparisons were made. In 56 cases, there was at least one of two plots in which the yield was above 500 kg/ha. We adopted this threshold because when plots are below 500 kg/ha, it is fairly clear that non-experimental variables dominate the varietal aspect of the trial rendering differences in production arbitrary.

An analysis of yield stability was also carried out using these tests. Taking the average yield of two plots as an indication of the environment, a simple regression analysis was performed between the yield of a chosen variety and the "environmental" index.

DJ-12-519 showed a relatively high regression coefficient (Table 32) which was significant. Senicoly had the highest intercept, however, indicating that yields were acceptable even under very difficult environmental conditions. What one sees in Figure 6 are classic curves for a good local variety (Senicoly) and several improved varieties. Up to 2,000 kg/ha, Senicoly is as productive as the improved varieties under farmers' conditions. At more productive sites, DJ-12-519 is the highest yielder.

TABLE 32

ANALYSIS OF YIELD STABILITY: LINEAR EQUATIONS FOR YIELD (Y) AND ENVIRONMENTAL INDEX (X)

Variety	N	Equation[a]	T-value
DJ-12-519	15	Y = 1.112 X + 111	1.62
IRAT 133	12	Y = 1.07 X + 48	0.99
IRAT 112	13	Y = 0.926 X + 0.4	0.66
144B/9	9	Y = 1.008 X - 75	0.05
Senicoly	10	Y = 0.900 X + 614	0.72

[a]Y and X are measured in kg/ha.

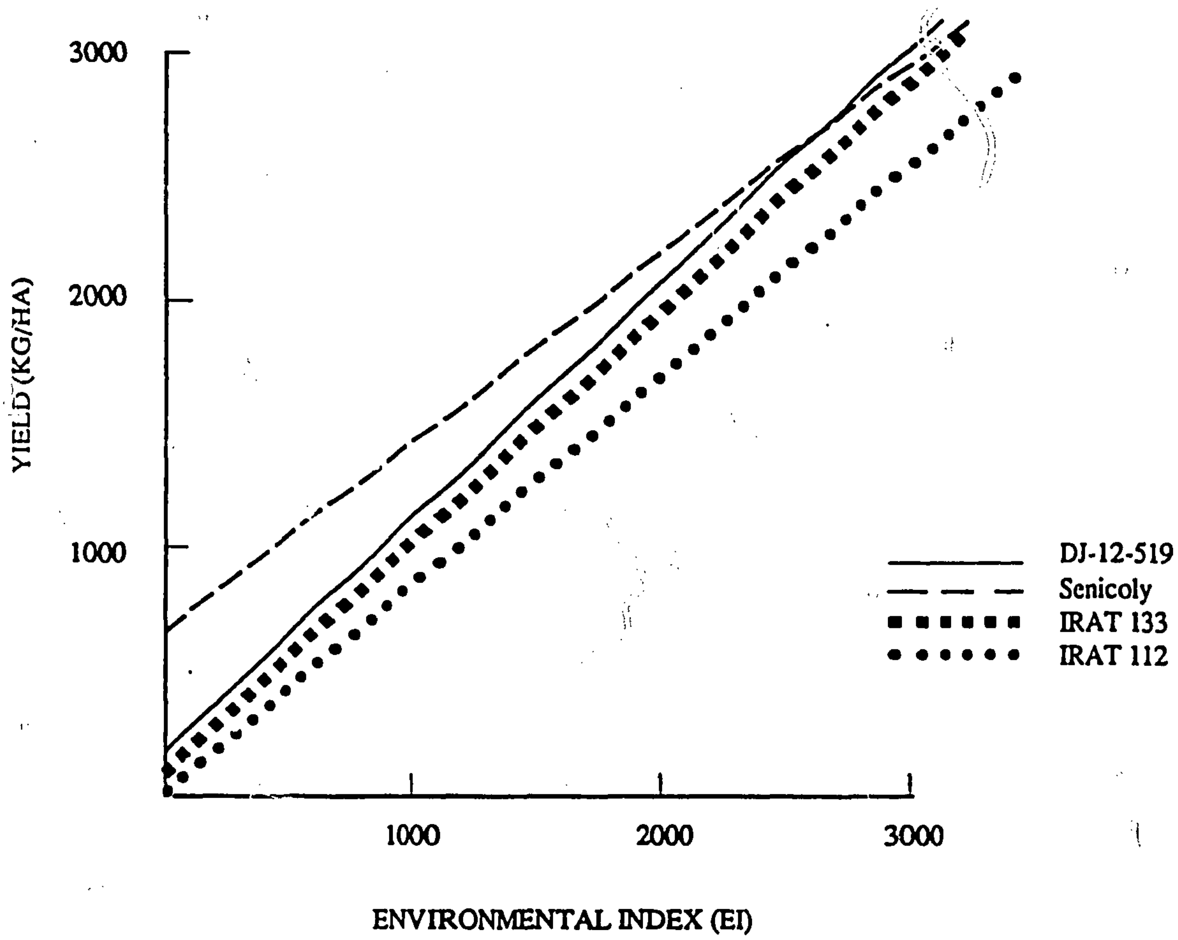

Figure 6

PADDY YIELD (KG/HA) AS A FUNCTION OF ENVIRONMENTAL INDEX (EI)
FIELD SIZED PLOTS
TRANSITIONAL ZONE RICE

With the exception of DJ-12-519, the regression coefficients were not significant. Therefore, another method of analysis had to be used. We established three categories of results in which the improved variety was (1) superior, (2) equal to, or (3) less than the local check. The frequency with which each improved variety fell into each category was then examined (Table 33).

Under the actual conditions of Casamance farmers, three varieties, DJ-12-519, IRAT 133, and Senicoly, the indigenous variety from Tendimane, produced as much or more than the control nine times out of ten.[27] This indicates that the varieties are especially robust and able to produce under very difficult conditions (e.g., a superficial tilling with a _fanting_, broadcast seeding, late weeding and the absence of insecticides and fertilizers). In another, better context, these same varieties will produce much higher yields. This was the case in Boulandor in 1985 where with 25% of the recommended dose of fertilizer, the yields for DJ-12-519 were 2.2 tons/ha. The previous year with no fertilizer only 1.6 tons/ha were produced.

D. Conclusions

These results suggest that the local extension agency (PIDAC) should begin promoting DJ-12-519, the improved variety, on transitional rice fields with heavy soils and adequate water. The benefits of IRAT 133 versus 144B/9 in the fields higher up the toposequence should be evaluated further.

The advantages of the improved varieties are their tolerance to rice blast and resistance to lodging. Moreover, their duration in the field is as short or shorter than those of the local varieties. Even so, given yields of only one to two tons/ha, the local varieties continue to be competitive and possess certain characteristics which are valued by farmers such as grain quality and plant height. Three local varieties, Barafita, Abdoulaye Mano, and Senicoly, should be retained for these reasons and because they are especially vigorous at emergence.

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[27] In general, in 75% of the trials, the improved variety was better or equal to the local variety.

TABLE 33

ANALYSES OF FIELD-SIZE[a] TESTS FOR TRANSITIONAL ZONE RICE: RESULTS BY VARIETY (1983-85)

Variety	Number of Trials	Abandon. Trials	Trial Yielding <500kg[b]	Trials Analyzed	Comparison[c]			Yields (kg/ha)	
					Better	Inter-mediate	Poorer	Improved Vars.	Local Vars.
DJ-12-519	18	3	3	12	8	4	0	2068	1433
IRAT 133	13	0	1	12	5	5	2	1761	1408
IRAT 112	18	5	0	13	3	3	7	844	1025
144B/9	22	12	1	9	3	2	4	1066	1203
Senicoly	13	2	1	10	7	3	0	2036	1010
Total	84	22	6	56	26	17	13	1551[d]	1220[d]

[a]Trial approximately $500m^2$ for each variety · farmer's level of inputs

[b]Tests in which neither the improved nor the local variety produced more than 500 kg/ha.

[c]Comparison: if the improved variety yields at least 20% more than the local variety, the variety is considered "better"; if it yielded 20% less than the local variety, it is considered "poorer". Yields between the two are considered "intermediate".

[d]Weighted means = $\frac{\text{Total Production}}{\text{Total Area}}$.

IV. VARIETAL TRIALS--AQUATIC RICE ZONE

A. Introduction

The object was to study and evaluate several improved varieties of aquatic rice within the traditional system of rice cultivation. The varieties chosen had been previously studied on-station and in multilocational trials conducted by the Rice team. One goal was to see how well the varieties would adapt to farmers' conditions.

B. Experimental Design

The study was carried out in two ways: as a varietal trial with two repetitions and as a field-size comparison between a vigorous local and an improved variety, the latter selected on the basis of the variety trial.[28] The five varieties compared in the varietal trial (see Table 34) were first planted in a nursery (50 gm of seed/m^2) and then transplanted (after 30 days) onto four ridges 10 m long in three rows with 25 cm between plants (500 plants/plot). For the field-size experiment, the dimensions varied considerably at different sites but the nursery contained plants 300 m^2 for each variety. Inorganic fertilizer was not applied in either type of trial.

C. Results

Of 16 varietal trials initiated, only 10 were analyzed. Five were abandoned because flooding occurred exceptionally late and the plants did not reach maturity. A sixth variety trial was lost due to iron toxicity.

Yields for the ten trials that were harvested proved very poor. Significant differences were observed in only two cases as Table 35 indicates. The field-size tests gave similarly low yields (Table 36). Poor yield notwithstanding, Rok-5 and DJ-684D are the best adapted varieties in the areas tested. Analysis of these tests proved difficult, however, because of the heterogeneity of the fields across villages. The elevation of the field and the level of iron toxicity, salt intrusion, and soil fertility intervened to varying degrees. The analysis by village (Table 37) reduced the variability somewhat, revealing that at Seleky and Boukitingo there is little research and

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[28]This trial was conducted with the collaborator of the Rice Research team, Djibélor.

TABLE 34

CHARACTERISTICS OF IMPROVED VARIETIES FROM THE VARIETY TRIAL (VT) AND ON-STATION STANDARDS (S) - AQUATIC RICE

	Cycle (days)		Height (cm)		Panicles/m^2		Yield (kg/ha)	
Varieties	S	VT	S	VT	S	VT	S	VT
IR-1529	125	133	100	80	305	129	4,500	1,465
BR-5146	125	128	90	81	381	102	5,000	1,256
DJ-684D	120	125	100	76	429	134	4,500	1,551
IKP	115	115	85	75	358	116	5,000	1,026
IR-442	125	120	120	85	362	101	4,500	1,287
Mean	122	124	99	79	367	116	4,700	1,251

TABLE 35

YIELDS OF VARIETAL TRIALS FOR AQUATIC RICE (1982-1985) (KG/HA)

Variety	Loudia-Ouoloff 1982	Loudia-Ouoloff 1983	Loudia-Ouoloff 1984 I	Loudia-Ouoloff 1984 II	Boukitingo 1982	Boukitingo 1983	Bandjikaki 1983	Bandjikaki 1985	Boulom Suel[a] 1982	Boulom Suel[a] 1983	Site Mean
IR-1529	250	1,163	1,184	1,460	1,991	1,883	578	2,900	1,733	1,509	1,465
BR-51-46	502	1,260	472	651	2,239	1,644	423	2,036	2,050	1,283	1,256
DJ-684 D	379	478	1,223	1,628	2,768	2,392	580	3,000	1,417	1,651	1,551
IKP	166	65	NP	NP	1,832	1,137	495	NP	1,550	1,934	1,026
IR-442	NP	NP	661	1,561	NP	NP	NP	1,639	NP	NP	1,287
Local	265	489	1,225	1,876	1,396	1,929	468	0	1,500	2,406	1,156
Mean	312	691	953	1,435	2,046	1,789	508	1,915	1,650	1,757	1,307
F-Test	NS	NS	9.4[b]	NS	NS	NS	NS	43.3[b]	NS	-	
CV %	39	95	17	22	16	28	9	14	58	-	
LSD .05 (kg/ha)	-	-	460	-	-	-	-	725	-	-	

[a]At Suel, the two repetitions were harvested together.

[b]Significant at 1%.

NP Variety not planted in the trial

Note: Trials had two repetitions with 4 ridges 10 meters long; inputs were minimal.

TABLE 36

ANALYSIS OF FIELD-SIZE[a] TESTS WITH AQUATIC RICE:
RESULTS BY VARIETY (1983-1985)

Variety	Number of Trials	Abandon Trials	Yields[b] <500 kg	Trials analyzed	Comparisons[c]			Yield (kg/ha)	
					Better	Interme-diate	Poor	Improved Vars.	Local Vars.
IR-1529	8	3	0	5	0	2	3	637	939
BR-51-46	6	0	2	4	3	0	1	834	663
DJ-684D	11	1	2	8	4	1	3	1897	1463
Rok5	8	1	1	6	4	0	2	2288	1647
Senicoly	9	1	0	8	3	0	5	1136	1373
Total	42	6	5	31	14	3	14	1162[d]	1288[d]

[a]Trial approximately 300m^2 for each variety - farmer's level of input.

[b]Tests in which neither the improved nor the local variety produced more than 500 kg/ha.

[c]Comparison: if the improved variety yields at least 20% more than the local variety, the variety is considered "better"; if it yielded 20% less than the local variety, it is considered "poorer". Yields between the two are considered "intermediate".

[d]Weighted means = $\frac{\text{Total production}}{\text{Total area -1}}$.

TABLE 37

RESULTS OF FIELD-SIZE TESTS WITH AQUATIC RICE BY VILLAGE (1983-1985)

Village	Trials Analyzed	Comparisons[a]			Yields (kg/ha)	
		Better	Interme-diate	Poorer	Improved Varieties	Local Varieties
Loudia-Ouoloff	4	4	0	0	1,431	658
Boukitingo	11	1	3	7	1,269	1,556
Seleky	8	1	0	7	943	1,535
Mahamouda	3	3	0	0	925	668
Boulandor	1	1	0	0	1,418	757
Bandjikaki	4	4	0	0	2,775	1,521

[a]Comparison: if the improved variety yielded at least 20% more than the local variety, the variety is considered "better"; it if yielded 20% less than the local variety, it is considered "poorer". Yields between the two are considered "intermediate".

extension currently has to offer the farmer as the local variety did better than the improved varieties. At Loudia-Ouoloff and Bandjikaki, however, the improved varieties were better.

D. Conclusions

Both in the agronomic surveys and the trials, the aquatic zone was found to be very variable and difficult to get a handle on experimentally. Moreover, the multitude of constraints related to the lack of rain (e.g., salt and iron toxcity; water stress) makes it very difficult to determine how to improve the system without involving engineering interventions such as pumps, drainage systems and anti-salt dams. Although we have little else to offer the farmer under these circumstances, it does appear that the improved varieties Rok-5 and DJ-684 do well in good fields. Among the local varieties tested, Mpack (from Boukitingo) and Essoboro (Seleky) were also very productive.

V. FERTILIZER TRIALS IN THE TRANSITIONAL RICE ZONE

A. Introduction

The object was to determine what level of chemical fertilization is economically profitable for production in the transitional rice zone. With continuing increases in fertilizer prices in Senegal (i.e., complete fertilizer in 1981; 25 FCFA/kg; 1985: 120 FCFA/kg; urea in 1981: 25 FCFA/kg; 1985: 90 FCFA/kg), it was hypothesized that transitional zone rice is a crop for which there would be a profitable return to investment in fertilizer. Previous studies on fertilizer use had been done in years when there was adequate rainfall and employing cultural practices that are better than those available to the average farmer (i.e., deep plowing, organic matter applications, several weedings, etc.). The trials described below were conducted in farmers' fields using typical cultural practices.

B. Experimental Design

The trial employed a randomized complete block design with four treatments and two repetitions. The treatments studied in 1982 and 1983 follow:

T1: Control plot, without fertilizer

T2: Application of 400 kg/ha of Taiba phosphate

T3: Application of 400 kg/ha of Taiba phosphate + 100 kg/ha 8:18:27 and 75 kg/ha of urea

T4: Application of 400 kg/ha of Taiba phosphate + 200 kg/ha of 8:18:27 and 150 of urea

In 1984 and 1985, phosphate was not applied to T3 and T4.[29] After manual land preparation, the trials were planted (80 kg/ha) in rows with IRAT 112 or IRAT 133. The plots measured 10 m X 10 m. At weeding, treatments 3 and 4 received a urea application (75 kg/ha and 150 kg/ha).

C. Results

Twenty-six trials were planted, but only 19 were harvested. Nothing was harvested in six out of six trials put on former abandoned rice fields (previously transplanted but recently in fallow), due to low rainfall and poor

[29] Basal applications of phosphate in T3 and T4 were eliminated in 1984 because the extension service was no longer selling phosphate fertilizer.

fertility. In very dry years, this zone, which is both very sandy (sand > 85%) and acidic (pH < 4.0), does not respond well to chemical fertilizer, especially when it is not complemented with organic matter.[30]

1. Stratification by Environment

When the results are examined in relation to soil type, three classes of rice fields are distinguishable: 1) those which are very acidic and sandy; 2) those with a greater clay content but which are also acidic; and 3) those considered to be "good" fields having a high clay content and a relatively high pH. Table 38 presents the three categories and their corresponding yields. In general, the first type is found on upper terraces near the mouth of the river. The low pH associated with the second type of field may be due to organic matter accumulation or stagnating iron-laden water near the edges of the valleys. The better fields are located in the inland valleys and on the right bank of the river in the Kalounayes zone.

2. Response to Basal Phosphate Applications

In contrast to what one would imagine, in fields that were very acidic basal phosphate applications did not show an effect compared to the control (1,226 vs. 1,281 kg/ha). In Tendimane where iron toxicity was a problem, and in Maoua which has histosols with an abundance of organic acids in the beginning of the rainy season, it is probable that the lack of phosphorus was masked by other phenomena.[31] In contrast, on good fields, basal applications of phosphate produced the desired effects (1,916 vs. 1,548 kg/ha). Response curves to NPK additions with basal phosphate (in 1982 and 1983) and

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[30]To better determine the fertilizer needs of the high, sandy fields, a trial was conducted at Djibélor station in 1984. The good rainfall received in June and July (602 mm) inundated the fields relatively early, resulting in complete submersion and few weeds. The control plot produced 752 kg/ha. Treatments with 3 tons/ha and 6 tons/ha of dry dung produced 1,366 and 1,469 kg/ha of rice, respectively. With half the dose of fertilizer (100 kg/ha of 8:18:27 and 75 kg/ha of urea), the plot yields were in the order of 1,650 kg/ha. The trial shows that in a wet year poorer fields can be cultivated but on the condition that a considerable amount of organic matter or some fertilizer is applied.

[31]Phosphorus was deficient at both sites (Olsen method). According to the analysis of C. Brade, an ORSTOM researcher, the concentration of organic acids at Maoua and ferrous ions at Tendimane were at the toxic threshold for rice in the paddies (personal comm.).

TABLE 38

PADDY YIELDS (KG/HA) BY TYPE OF RICE FIELD: FERTILIZER TRIALS WITH PHREATIC RICE

Type of Rice Field	Soil Characteristics	Number of Trials	Control	100kg/ha 8:18:27 75kg/ha urea	200kg/ha 8:18:27 150kg/ha urea	400kg/ha Taiba Phosphate	F-Test
Marginal	sandy, acid	6	-	not harvested			
	very acidic (pH<3.5)	5	1,281	1,419	1,533	1,226	NS
Productive	less sandy (clay >20%) less acidic (pH>4)	14	1,548	2,371	2,656	1,916	12.9[a]

[a]Significant at 1%.

NS = Not Significant

without basal phosphate (1984 and 1985) did not show a significant difference, however. This result should be interpreted with caution, however, as the comparison was based on years when the rainfall varied substantially. In addition, the sites were not consistent from one year to the next.

3. Response to Complete Fertilizer (NPK)

Analysis of variance showed that inorganic fertilizer alone is not effective on highly acidic fields. However, a significant effect was found for the "good" fields.[32]

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[32]ANOVA - Fertilization of "good" fields:

Source	df	Mean Square Error	F-test	Prob.
Site	8	1,296,844	7.78	.001
Treatment	3	2,155,512	12.93	.001
Error term	24	166,663		

LSD.05 = 401; CV (%) = 19.2

To calculate the optimal dose of fertilizer, a quadratic regression was run:

$Y = 1515 + 6.53\ x - .009\ x^2 \qquad R^2 = .37$

(x = kg of fertilizer 8:18:27 + urea in the proportion: 1:0.75; n = 51 cases).

The equation shows the maximum dose of fertilizer to be 391 kg (224 kg/ha 8:18:27 and 168 kg/ha of urea) and the optimal dose, 329 kg (assuming that the prices of fertilizer--both compound and urea--as well as paddy were equal to 100 FCFA/kg). Such large quantities of fertilizer are beyond the means of most farmers.

Taking nutrient replacement as a point of departure, one arrives at still other conclusions. For example, if the goal is 2.5 tons of paddy and as much straw, the nutrient removal--according to work done at the International Rice Research Institute--is much less than what is being added when one uses the current fertilizer recommendations (Table 39). In fact, with half the amount recommended, nitrogen and phosphorus requirements could easily be met.

TABLE 39

RECOMMENDED FERTILIZER LEVELS AND ESTIMATED UPTAKE IN A HARVEST OF 2.5 T/HA OF PADDY AND RICE STRAW

	kg of nutrients		
	N	P_2O_5	K_2O
Recommended additions[a]	83	36	54
Estimated uptake	48	11	117

[a]Recommendation: 200 kg/ha of 8:18:27 and 150 kg/ha of urea.

Source: IRRI Annual Report, 1963.

In the case of potassium, the actual off-take is a fraction of the quantity noted, as 95% of the potassium uptake can be found in the straw which remains in the field after harvest.[33]

With half the recommendation (T3), yields were 2,371 kg/ha. At this rate, nutrient off-take would be approximately in balance with inputs and total fertilizer outlay (47,500 CFA/ha) would be more affordable.

D. Conclusions

Two main conclusions emerge from the fertilizer trials with transitional zone rice:

1) Fields which are both very sandy and acidic do not respond to fertilizer.

2) In "good" fields, local cultural practices and the effect of drought stress limit yields to such an extent that the amounts of fertilizer currently recommended are greatly in excess of that required.

Soil scientists should be collaborating with breeders, farming systems researchers and extension leaders in an effort to identify fields which will respond to fertilizer, and to develop acceptable production packages for these areas.

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[33]This method of reasoning only provides an approximate nutrient budget. A positive factor not included in the formula is the native fertility of the soil (the control produced 1,548 kg/ha). On the negative side, fertilizer loss during the cycle due to variable anaerobic conditions must also be considered.

VI. HERBICIDE USE (RONSTAR 250 CE) WITH DIRECT-SEEDED RICE

A. Introduction

Weed control[34] constitutes one of the principal constraints in the transitional rice zone in Lower Casamance. Regression analysis on data from the agronomic survey indicated there is a decline in yield of 180 kg/ha of paddy for each week weeding is delayed. Moreover, the labor study indicates that over a third of the work time required to grow rice is for weeding.

To determine how such a labor bottleneck might be reduced, the effect of employing a systemic herbicide Ronstar 250 CE (Oxadiazon 250 gm/l) within the traditional farming system was examined. First, simple comparisons of treatments with and without herbicide (binomials) were conducted. Then, the scale of the trial was expanded and all the fields of four farms in two study villages were treated. This was an effort to determine the impact of a reduction in weeding time on the returns to womens' labor overall.

B. Experimental Design

The experiment involved two plots of 300 m^2. One was treated with Ronstar 250 CE (Oxadiazon 250 gm/l) at a rate of 4 l/ha prior to emergence.[35] The other was grown without herbicide. In most cases the two plots were tilled with the fanting. The farmers' chosen varieties were used in this experiment as were their methods of planting--either broadcast or in rows. In the third year of the study (1985), all the plots of two farms in Boulandor and Maoua were treated. The production strategies used on these two farms were then compared to the village average.

C. Results

The team put in 29 trials of which 26 produced reliable yield and labor time measurements. Young plants in four plots on the exceptionally sandy soils of Tendimane showed evidence of phytotoxicity which had a disastrous effect on yield. In four other plots, women delayed weeding the treated

[34]The main weeds found in the transitional rice zone are the Gramineas (i.e., Echinocloa, Panicum, Paspalum and Digitaria).

[35]A Cosmos backpack sprayer with a one meter spray boom was used. The application rate was 225 l/ha of water--at a walking speed of 60 meters per minute.

subplots (over two weeks), allowing the second flush of weeds to adversely affect yields. Of the remaining 18 tests, use of herbicide was found to be profitable in 16 of the simple comparisons between treated and non-treated subplots. (This calculation takes into consideration the value of paddy less the direct costs of the herbicide and weeding.)

The effect of chemically controlling weeds on yield was weak (shown in Table 40a), except in a dry year such as 1983. That year, the drought kept farmers from carrying out hand weeding and as a result the plots with herbicide had a considerable advantage.

The effect of herbicide on labor time was even more pronounced. Across the board, we find that plots treated with herbicide required only about a third of the time devoted to weeding the untreated plots (Table 40b). The difference is even greater at Medieg where women broadcast their seed, which requires pulling out the weeds by hand. In contrast, the relationship between labor time and herbicide use is not as strong in Boulandor where women plant in rows and weed quite efficiently with a hoe. At Tendimane (where the ridge and furrow method of land preparation is practiced), weeding takes less time than anywhere else, demonstrating the positive weed management effects of using the cayendo.

The use of herbicides becomes more and more advantageous the longer weeding is delayed. The labor time involved for weeding when herbicide is used versus without it (if weeding is done in the first 35 days following planting) is in the order of 1 to 2.3. After 35 days has passed, the ratio is 1 to 6.7. The same relationship does not hold for yields, which differ only by 10 to 20% in all the tests conducted. This is explained by the fact that women plan how they will weed; they work first on the plots which are most in need first and later those which are less weedy. This strategy maximizes their rice production on a whole farm basis.

In the case where all the plots on four farms were treated with herbicides, we observed two different strategies. At Boulandor, yields of the treated plots were not greater than the average for the village but women used the time saved for planting a greater area in rice. Instead of weeding phreatic rice earlier, they moved further down the toposequence to cultivate aquatic rice. In contrast, at Maoua where the women owned no aquatic rice fields, they invested the time gained in tending their transitional zone fields with the result that their yields were higher than the village average.

TABLE 40

EFFECT OF HERBICIDE APPLICATION ON YIELD (A) AND LABOR TIME (B) IN THE TRANSITIONAL ZONE RICE

A. Effect on yield of paddy (kg/ha)

Year	N	Herbicide[c] Applied	No Herbicide	F-Test
1983	7	1412	937	17.65[a]
1984	17	1807	1650	NS
1985	5	1461	1292	NS
All	29	1651	1416	9.34[a]

B. Effect on labor time (labor days/ha)

Village	N	Herbicide[c] Applied	No Herbicide	F-Test
Medieg	7	18	101	54.0[a]
Boulandor	10	35	87	14.7[a]
Tendimane	3	5	20	18.6[a]
Boulom	5	16	48	7.6[b]
All villages	26	22	71	41.9[a]

[a]Significant at 1%

[b]Significant at 5%

[c]Ronstar 250 CE (Oxadiazon 250 gm/1; 4 1/ha).

D. Conclusions

In 16 of 26 tests, simple comparisons of the cost of field labor and the price of herbicide on the one hand, and the gross value of the rice produced on the other, show that herbicide use is profitable. On sandy soils (4 cases), some degree of burning was observed, indicating the need to reduce the amount of Ronstar 250 CE. In four other cases, the excessive delay in weeding the treated plots resulted in a yield reduction, consequently the use of herbicide was uneconomic. However, this is the case only at the level of the individual plot since subsequent whole-farm analysis showed that with the time gained in using herbicide, additional fields were planted.

The use of herbicides (either pre- or post-emergence) should be considered as part of the credit program available to Casamance farmers. Herbicide application even on half of the compound's rice fields will have a beneficial effect on the production of paddy across all of the rice fields.

VII. TESTS WITH ANIMAL-DRAWN SEEDERS

A. Introduction

The majority of rice fields in Lower Casamance which are direct-seeded are sown by broadcasting. While this method is relatively rapid, it requires women to hand pull weeds. Row seeding facilitates weeding with a hoe but is time consuming when done by hand. The object of the trial was to see if the UCF plow and the Super-eco planter, equipped with disks for planting peanuts (24 holes) can be used successfully to row seed rice in the transitional zone.

B. Experimental Design

In Medieg and Boulandor where the use of animal traction is widespread, rice fields of 5 to 10 ares were identified for inclusion in the study. Half of a field was tilled with a fanting, while the other half was prepared with a UCF plow. Afterwards, the bands were divided in two parts, one of which was broadcast, the other planted with a Super-eco seeder.[36]

The tests in 1984 used 144 B/9 with a separation of 45 cm between rows when planted with the seeder. No fertilizer was added. In 1985, fertilizer was applied (100 kg/ha of 8:18:27 and 75 kg/ha of urea) and the spacing between rows was 30 cm.

C. Results and Discussion

The results of four of the original six tests carried out according to the protocol are summarized in Table 41. The use of a UCF plow produced yields which were somewhat higher than those obtained when the field was prepared with the "fanting" (1,763 vs. 1,540 kg/ha), but the difference was not significant. With respect to labor, the plow required about two-thirds less time than the "fanting" (13 person-days/ha versus 36 person-days/ha). This estimate was calculated on the assumption that two men and a pair of oxen take 6.5 days to plow one hectare. Use of the seeder allowed more rapid planting than the broadcasting method (7 person days/ha instead of 11[37]), but had a negative effect on yield. This can be attributed to the decision

[36] In this analysis the trial was treated as a strip-plot.

[37] Planting time with the seeder is somewhat overestimated due to the lack of experience farmers have with animal traction in the rice fields.

TABLE 41

YIELD OF PADDY (KG/HA) AND LABOR TIME (PERSON DAYS/HA) FOR MODE OF PLANTING TRIALS IN THE TRANSITIONAL RICE ZONE

	Field Preparation and Mode of Planting				
	"Fanting" (hand hoe)		UCF Ox Plow		
Variable	Broadcast	Seeder	Broadcast	Seeder	F-Test
Yield (kg/ha)	1678	1404	1934	1592	NS
Total labor time[a] days/ha	190	124	166	100	5%
Land preparation	36	36	13	13	NS
Planting	11	7	11	7	NS
Weeding	142	80	142	80	5%

[a]Total labor time (labor days/ha; 8 hr/day) includes land preparation, planting and weeding but not harvesting. In the few plots where harvest time was measured, the amount ranged from 10 to 30 kg of paddy harvested a day, or an average 21.5 kg/day.

NS = Not Significant

taken to maintain spacing at 45 cm between rows in 1984 (75 kg/ha of seed used). The more uniform density achieved by broadcasting (100 kg/ha) turned out to be more productive. In 1985, when the spacing was 30 cm, yields for plots which were row planted versus those broadcast were equal.

The net effect of using the planter can be seen most clearly by examining the time spent weeding. With row seeding, women required only 50% of the typical time needed to weed plots which are broadcast. The difference is significant at the .05 level.

D. Conclusions

The use of animal traction in the rice fields is evolving slowly. The animals and equipment (plow, planter) normally belong to the men in a family and since they are fully engaged with upland crops in the beginning of the rainy season, women cannot count on their aid during this period.

The above constraint notwithstanding, planting dates for upland and lowland crops do not overlap completely. Millet and groundnuts can be put in before the rice fields are sufficiently wet to plant. Thus, it is not impossible that some of the rice fields can be plowed and planted with oxen. However, it is necessary to keep in mind the moisture and texture of the soils. Heavy soils must be wet in order for oxen to work them. With a fanting, even a dry soil can at least be broken up into clods.

The introduction of the planter alone would still be very advantageous in reducing women's work. If the women in each valley, through their cooperative groups, could find a way to hire men with animal traction, planting rice could be accomplished quickly using seeders. The work could even be done in the late afternoon after the oxen have already returned from the plateau. Using donkeys is also a possibility and one the women could manage more easily on their own. Another option is the two-row hand seeder (SISMAR, model Casamance) which cost approximately 29,500 FCFA in 1985, not an impossible sum for a women's organization. The widespread adoption of row planting rice fields would present research with a new challenge--that of mechanical weeding techniques. This topic will have to be addressed in future research.

VIII. MODE OF PLANTING--A COMPARISON OF DIRECT-SEEDED AND TRANSPLANTED RICE ON SANDY UPPER TERRACES

A. Introduction

With the rainfall deficit of the last 15 years, direct seeding has gained importance in the Lower Casamance, to the detriment of transplanted rice. Direct seeding has not been adopted in some areas of the Blouf and in the Department of Oussouye, where transplanting remains the dominant practice. In an effort to understand why some farmers resist this innovation, a trial comparing direct-seeded and transplanted rice was initiated on a sandy field typical of those found in the ancient flood plains of the Casamance River.

B. Experimental Design

The basic design of the experiment was a randomized complete block with three treatments and four repetitions. The treatments (modes of planting) studied were the following:

T1: ISRA system--flat plowed, planted in rows with a planting rake (30 cm between the rows);

T2: Traditional (Tendimane) method--ridge and furrow; broadcast seeding on the top of ridges (60 cm wide 30 cm between furrows) made with a cayendo;

T3: Transplanted system--ridge and furrow tilled in two phases; transplanted near the end of August (3 lines/ridge);

The trial was laid out at the Djibélor station on a sandy transitional zone rice field (sand = 95%; pH = 4.5). The trial was conducted for three years (1983-85). Each plot was 190 m^2.

The first year, all plots received fertilizer (100 kg/ha of 8:18:27 at plowing and 75 kg/ha of urea one month after planting/transplanting). In the second and third years, chemical fertilizer was replaced by 2.5 t/ha of dry cow dung.[38] The direct-seeded plots were planted using 70 kg/ha of seed. Senicoly, a "good" local variety was used. It comes from Tendimane where the rice fields are both sandy and acidic.

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[38]The laboratory analysis of the cow dung showed the following:

% M.O. = 19.6; N total = 7400 ppm; P_2O_5 (exchangeable) = 2.49ppm; K_2O (exchangeable) = 6.24 ppm.

C. Results

The comparison between the three modes of planting was done for both yield and labor time data.

1. Yield

During the first year (1983) which was dry, the two direct-seeded treatments outyielded the transplanted treatments (Table 42a). This tendancy was reversed during the next two years. With the application of a small amount of organic matter (2.5 t/ha of dry dung or the equivalent of 18.5 kg N; 6.2 kg P_2O_5; 15.5 kg K_2O) and more rain, transplanted rice produced better. Direct seeding in sandy, acidic fields was affected both by low fertility and iron toxicity. In constrast, transplanting took place in a more favorable milieu. That is, by the end of August, the pH had increased to 5.8 and the water entering the field from the water table[39] supplied certain needed elements. The peak of soluble iron concentration, associated with the beginning of flooding, was also avoided.[40]

It appears that low soil fertility before flooding keeps farmers from direct seeding, with good reason. They are often unable to obtain chemical fertilizers and do not have enough organic matter to improve fertility. In a trial situated adjacent to the mode of planting trial in 1984 (see footnote 31), plots without fertilizer produced only 752 kg/ha, while with 6 tons/ha of dry dung, yields were more acceptable, on the order of 1,500 kg/ha.

2. Labor Time

Both the total labor time (Table 42b) and the distribution of time for tasks differed between the plots which were direct-seeded and those that were transplanted. First, the direct-seeded system (T2) typically used by farmers is somewhat more rapid than the one proposed by the research team (T1). Yields for both systems are similar, however. While the ridge and furrow sys-

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[39]One estimate shows that on transitional soils, the phreatic water table supplies 30 to 60 kg of nitrogen per hectare per year (Ganry and Pocthier, 1982).

[40]Beye et al., (1979) find that the content of soluble iron is often high during the first six weeks of flooding.

TABLE 42

YIELD (A) AND LABOR TIME (B)
IN MODE OF PLANTING TRIAL

A. Yield (kg/ha) - Senicoly variety

Year	Rainfall (mm)	Direct Seeded T_1	T_2	Transplanted T_3	F-Test
1983	807	1,836	1,846	767	46.3[c]
1984	1,259	1,057	933	1,647	24.7[c]
1985	1,258	746	688	1,366	6.9[b]

B. Labor time[a] (minute/190m^2)

Year	Direct Seeded T_1	T_2	Transplanted T_3	F-Test
1983	1,278	1,061	686	22.4[c]
1984	1,146	959	936	3.3(11%)
1985	1,194	991	1,005	3.3(11%)

T_1 Recommended

T_2 Farmer technique

T_3 Traditional transplanted technique

[a]Field preparation (measured) + time for planting/transplanting (measured) + weeding time (measured) + time to create the seedbed (estimated) + time to remove plants from seedbed (estimated); time for harvesting (not included)

[b]Significant at 5%

[c]Significant at 1%

tem resulted in an unequal distribution of plants (they were all on the ridge) compared to flat plowed land, paddy yields were not significantly different across the three years of the study.[41] Broadcast seeding is more rapid than using a planting rake, and weed control on the ridges is improved.

The second observation which emerges is that transplanting takes less time than direct seeding, overall. (This was also a finding of the survey data; see Table 26.) More important is the distribution of labor during the agricultural season. As can be seen in Figure 7, direct-seeded rice requires considerable attention during July and early August. This puts it in direct competition with the time required for upland crops such as maize, millet and groundnuts during that period. Transplanted rice, on the other hand, leaves farmers free through late August and thus fits better with the upland crop schedule. Thus, it is obvious why direct seeding poses a problem for farmers in the Oussouye and Blouf regions. The drought has forced them to adopt direct seeding with the result that they find themselves overextended at the beginning of the season when upland crops also require their attention.

D. Conclusions

The reluctance with which certain Diola farmers have accepted direct-seeded rice is hardly unreasonable. In the high, sandy fields, poor soil fertility and iron toxicity make direct seeding infeasible, particularly since fertilizer is too expensive. Moreover, direct seeding requires field labor just when farmers have other demands on their time.

The problems encountered in these zones should be addressed by attempting a more comprehensive approach to production, not simply by promoting a single strategy--direct seeding of short cycle rice varieties. The constraints posed by poor soil fertility and an overburdened agricultural calendar must be taken in account by planners. The use of chemical fertilizers or organic matter is critical, as is the introduction of animal traction. Promoting the adoption of the latter would allow farmers the time to adequately tend their upland crops as well as to devote time to their wives' direct-seeded rice.

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[41]Ridge and furrow tillage during dry years can have a negative effect on yield, however, because plants do not receive an adequate supply of water.

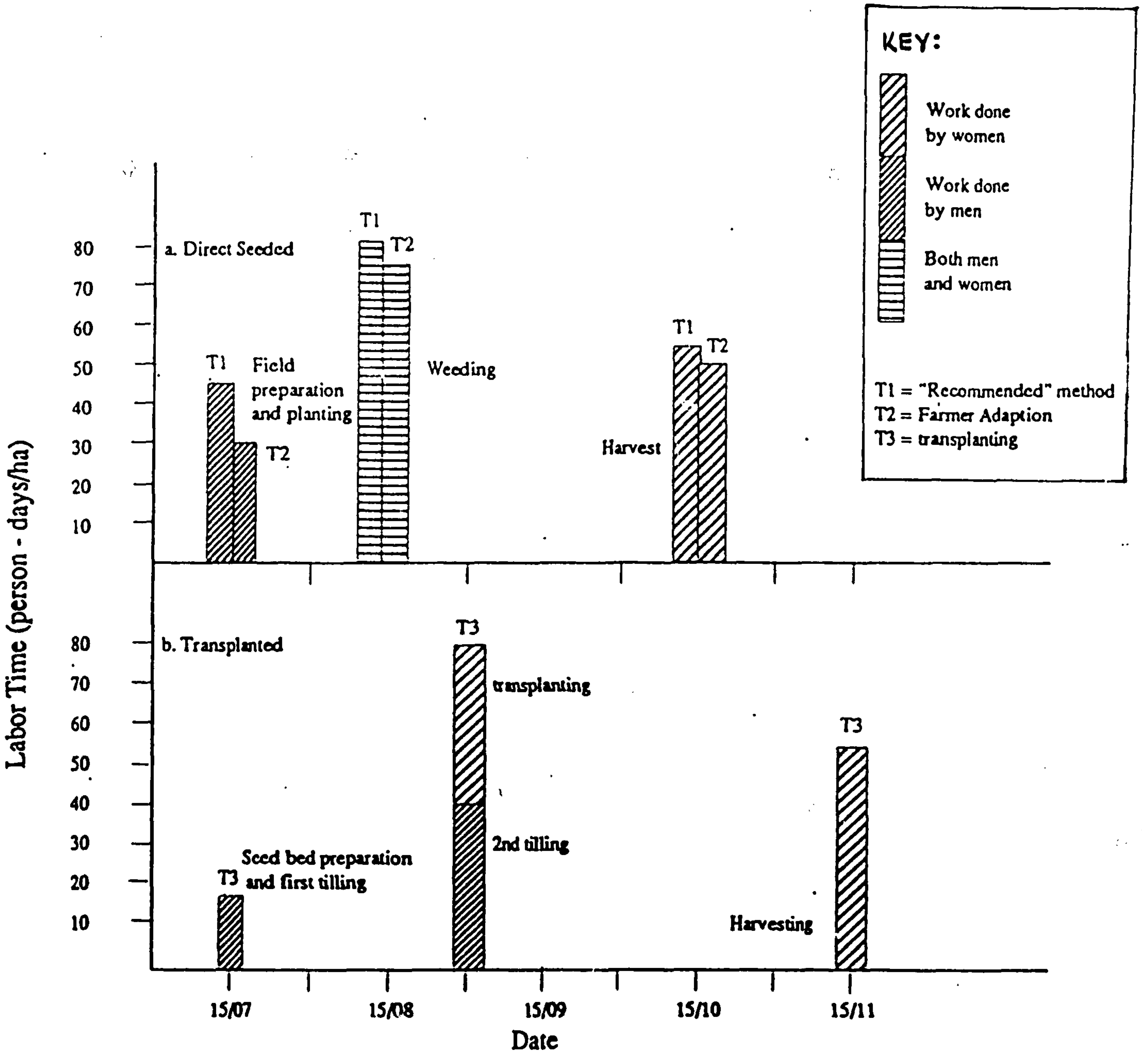

Figure 7

DISTRIBUTION OF WORK TIME - MODE OF PLANTING

IX. COMPARATIVE STUDY OF MAIZE AND RICE ON THE UPPER SLOPES OF THE TOPOSEQUENCE

A. Introduction

Villages in the Lower Casamance are generally situated near the edge of the plateau within close proximity to one of the tributaries of the river. On much of the land below these villages, rice production has been abandoned due to the falling level of the water table. In an attempt to increase productivity on the fields which have become marginal for rice, the team compared rice and maize along a toposequence. The interest in maize is that it requires less weeding and is more drought resistant than direct-seeded rice. The constraints imposed by maize production are two: maize does not do well in flooded areas and it requires adequate soil fertility. To determine where in the toposequence maize might be able to replace rice, a band of each crop was planted along the slope.

B. Experimental Design

The two bands (13.5 m wide by 78 m long) were oriented in the direction of the slope. At 13, 39 and 78 meters, access wells were installed in the central alley to a depth of 2 meters. The wells made it possible to monitor the height of the water table at three levels in the toposequence: high, intermediate and low. At the beginning of the rainy season, each band was plowed with a tractor and planted[42] with corn (ZM-10) and rice (144 B/9). Each year the place of the two crops was rotated.

The rice crop received 200 kg/ha of 8:18:27 and 150 kg/ha of urea each cycle. The corn fertilization rate was 200 kg/ha of 8:18:27 and 200 kg/ha of urea. Each crop was planted at the recommended density (rice: 70 kg/ha and 30 cm between rows; corn: 25 kg/ha, and 90 x 25 cm between hills) and each received one or two weedings depending on need.[43] At harvest, the bands were divided into three parts (high, intermediate and low), in order to compare yields of the maize-rice pair at each position in the toposequence.

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[42]Date of planting for rice and maize were: 11 July 1982, 5 July 1983, and 3 July 1984.

[43]At planting, rice was treated with Ronstar 250 CE (4 l/ha) and the maize with Gesaprim 500 (5 l/ha).

C. Results

1. Water Table Monitoring and Soil Analyses

The rainfall pattern changed each season resulting in a water table regime that differed each year (see Figure 8 a, b and c).[44] In the upper part of the toposequence, the water table never rose to within one meter of the surface. The highest point was reached in mid-September in 1982 and 1983, and in the beginning of August in 1984. In the lowest area, the water table was almost at the surface (-20 cm) during the wet years (1982 and 1984). In a dry year (1983), it remained far below the surface (> 100 cm). However, the period of surface flooding of the low-lying area was from the beginning of August to the end of September in 1984; in 1982, it occurred between mid-September and the end of October. There was no surface flooding in 1983.

In addition to their divergent water regimes, the upper and lower bands of the toposequence are located on soils of different textures and fertility (Table 43). The surface horizon of the soil (0-20 cm) in a low area is heavier and richer in nitrogen, phosphorus and organic matter than the soil higher in the toposequence. The interaction of water supply and soil type affected the yields of rice and maize.

2. Yields

Yields for maize on the upper and middle areas of the toposequence during the first two years, averaged 2 to 2.9 tons/ha. In 1984, however, which was a good year for rain (1,258 mm), yields fell. Despite the light texture of the soils, the substantial rains of June and July (603 mm total) created temporary flooding throughout the band. In the lowest band, two years out of three, maize did not produce. In 1982 when the rains were regular but not overabundant, the water table did not approach the surface until the late grain filling period, and a good crop of maize (2,400 kg/ha) was obtained.

The best yields (2.5 ton/ha) for rice, like maize, were obtained from the middle areas of the toposequence. Although flooding did not negatively affect rice in the upper regions, yields were only mediocre. This was due to the low natural fertility of the soils, which were particularly deficient in zinc. Once again, the high, sandy rice fields demonstrate that they do not

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[44]The average slope of the bands was 1.4% with a difference in height of 50 cm between the first and second access wells.

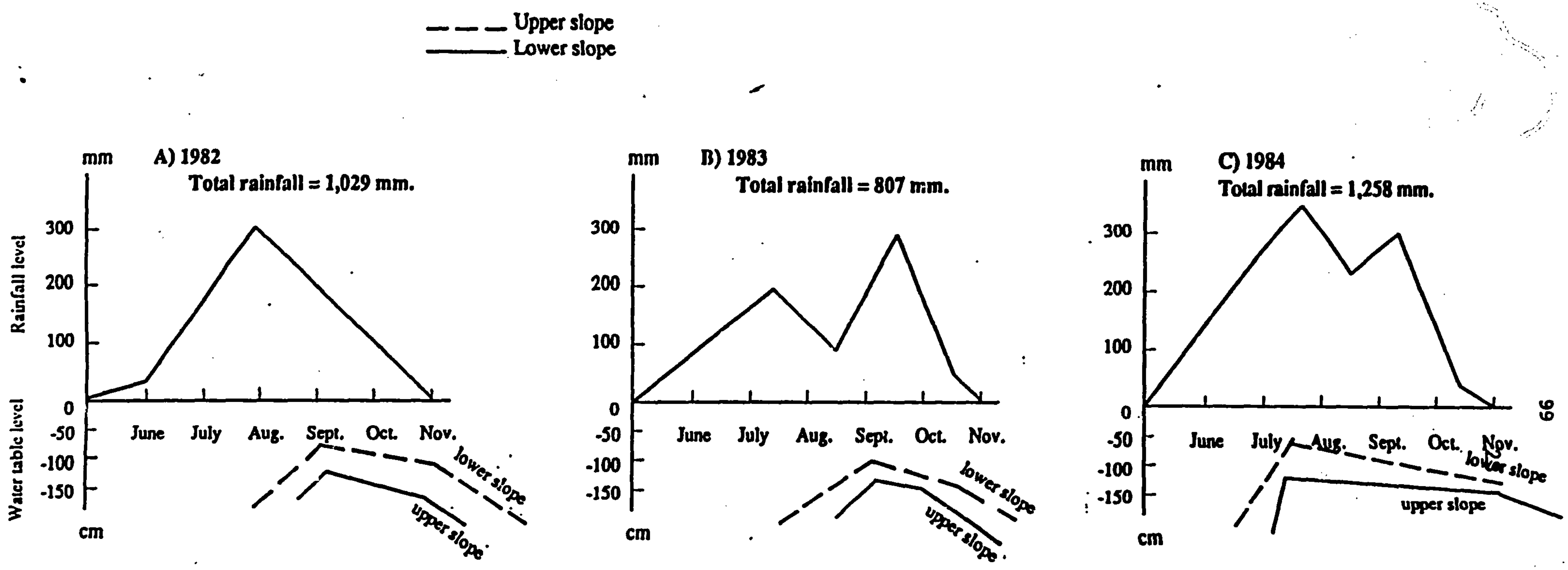

Figure 8

RAINFALL PATTERNS DURING THE STUDY YEARS AND THEIR EFFECTS ON THE HEIGHT OF THE WATER TABLE

TOPOSEQUENCE TRIAL 1982-1984

TABLE 43

RESULTS OF SOIL ANALYSES AND RICE AND CORN YIELDS IN THE DJIBELOR TOPOSEQUENCE TRIAL (1982-1984)

	Soil Analyses (0-20 cm)							Yield (kg/ha)							
	Texture (%)							Rice				Corn			
Toposequence	clay	silt	sand	pH	OM %	N_T (ppm)	P_{avail} (ppm)	1982	1983	1984	Mean	1982	1983	1984	Mean
High	2.6	1.9	95.5	5.4	0.6	180	1.8	1160	1834	762	1252	2006	2061	972	1679
Intermediate	6.7	3.4	89.9	5.4	1.2	-	3.4	2342	2868	2336	2515	2929	2813	1637	2460
Low	9.8	7.2	83.0	5.4	1.7	717	6.1	1012	2475	1854	1780	2382	964	510	1285

OM = Organic matter

N_T = Total nitrogen

P_{avail} = Available phosphorus - Bray I

Soil analyses conducted at Djibelor laboratory.

readily lend themselves to direct-seeded rice (see Trial III and VI).

In the low areas where we expected the best rice yields, we barely achieved adequate production in 1982 and 1984. The first year, small animals caused a considerable amount of damage, and in 1984 stem borers and iron toxicity which accompanied early flooding also had deleterious effects on yields. Nevertheless, in general our results indicate that the lower part of the toposequence should be reserved for rice production, even during the current period of drought.

D. Conclusions

In an attempt to see whether high sandy fields, formerly used as nurseries but now abandoned, could be re-established with corn, we compared corn to rice across the entire length of the toposequence for a period of three years.

In the upper fields, despite using the recommended level of fertilizer, after two cycles the plants began to show zinc and potassium deficiency. Thus, cultivating these areas will require a substantial dose of organic matter[45] as well as chemical fertilizer.

With respect to flooding, the land which is situated adjacent to the stream bed is too wet for corn during the agricultural season.[46] Higher up, flooding poses less of a problem, but when the early part of the season is rainy, temporary inundation of these soils often occurs with an accompanying reduction in yield.

In evaluating the total land holdings of the village, it is clear that there are other sites which are more promising for corn than the upper rice fields. The plateau would be more appropriate if adequate fertilizer and animal tethering for organic matter were used. As a future research theme,

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[45] In the fourth year of the study (1985), maize and rice were eliminated in the upper bands. A crop of cowpeas was put in to enrich the soil. Six tons/ha of dry dung was also added. The average yield for cowpeas on the high fields was 290 kg/ha. Yield for cowpeas on the middle band was 570 kg/ha.

[46] Since 1955, there have been 10 rainy seasons out of 31 in which the total rainfall for June and July exceeded 500 mm; 18 seasons received more than 400 mm of rain.

the potential of cowpeas, sweet potatoes and sorghum in the upper rice fields[47] should be considered. If the land is prepared using the ridge and furrow method which reduces the risk of flooding, and if planting is started late (mid-August) to take advantage of the slack in the agricultural calendar, it might be possible to re-establish these strategic lands in crops.

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[47]During two years of tests (1984 and 1985), sweet potatoes produced 6.4 tons/ha on average; transplanting was done at the end of August.

X. RECESSIONAL SWEET POTATO TRIALS

A. Introduction

In the Ziguinchor region, valleys located near urban areas are often used for vegetable production during the dry season, taking advantage of the accessible market. Water for the gardens is supplied by small hand-dug wells.

With the urban market in mind, we studied the possibility of growing sweet potatoes as a recessional crop. In principle, the crop would mature with the residual moisture in the soil, augmented by the capillary fringe of the retreating water table. Thus it would not require watering. In 1982, a comparison of maize, millet, cowpeas and sweet potatoes was conducted. The only crop which produced was sweet potatoes. Yields were in the order of 4 to 7 tons/ha. During subsequent years, we experimented further with the system of sequentially cropping sweet potatoes after rice.

B. Experimental Design

Three types of trials were conducted. The first was carried out along the edge of the inland valley at Djibélor. Once the rice seed multiplication plots were harvested, we began transplanting three varieties of sweet potatoes (10B-15, Ndargu, and 25-32). Transplanting continued from the end of September (for the high band after the harvest of a short cycle rice variety) to the beginning of November (the lowest band). Each band comprised 450 m^2 divided in three parts, 150 m^2 per variety. The transplanted areas were not fertilized, but the previous rice crop had received 200 kg/ha of 8:18:27 and 150 kg of urea. After the rice harvest, a pair of oxen with a UCF plow prepared the field, creating ridges every 70 cm. Sweet potatoes were transplanted in two rows, with 30 cm between cuttings on the top of the ridge.

The second type of experiment involved trials conducted in farmers' fields. Participating farmers transplanted sweet potatoes after the rice harvest in plots which had been used in variety tests (see trials I and II). These tests were managed by the farmers themselves and did not include fertilizer applications. The area of the plots varied from 300 m^2 to 800 m^2.

The third type of trial examined the use of fertilizer at the time of transplanting. On four high, transitional zone rice fields and two aquatic zone fields, three different doses of fertilizer were compared: T1 = no fertilizer: T2 = 100 kg/ha of 8:18:27 basally and 75 kg/ha of urea at 30 days;

T3 = 200 kg/ha of 8:18:27 basally and 150 kg of urea at 30 days. The variety used was 25-32. The plots had 2 to 4 furrows which were 10 meters in length.

C. Results

1. Effect of the Toposequence

The results of the trials for 1983 and 1984 at Djibelor are shown in Figure 9.[48] Rainfall in 1984 was better than in 1983, thus yields that year were higher. It is also apparent that the middle of the slope (Bands II and III) is the most productive zone. Band I is too high to double crop successfully, even when transplanting is completed by the end of September.

Band IV, which is not free from standing water until the middle of November, is also unsuitable for double cropping. In this area, the water table descends rapidly (2 cm/day) and because of a heavy silty-clay surface horizon, capillary action is not sufficient to meet the needs of the crop in the month of January (Evaporation class A pan = 6 mm/day).

The white skinned sweet potato (10B-15) is not very productive in a dry year, but does relatively well when rainfall is adequate (producing between 5 and 8 tons/ha of marketable tubers). The red skinned variety (Ndargu) is more adaptable and did well in both dry and wet conditions as well as at different dates of transplanting. Unfortunately, red skinned sweet potatoes are not as easily sold in the Ziguinchor markets as the white skinned type which explains why farmers are more interested in growing the latter.

2. Tests Under Farmers' Conditions

Twenty-seven demonstration trials were conducted with sweet potatoes between 1983 and 1985. The results are presented in Table 44. Most of the tests were done with Ndargu, the red skinned variety, or another local adaptation called "Chinois" which has white skin. In general, yields were less robust than those recorded on station. However, at 100 FCFA/kg, the gross profit on 500 m^2 varies between 8,000 and 12,000 FCFA depending on the yield obtained.

The marketable percentage for the demonstration plots as well as those on station varied between 50 and 80%. Weevils (<u>Cylos functiacollis</u>) were a

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[48] In 1985, due to the fact that we had no field watchmen, much of the crop was stolen, thus the results are not presented.

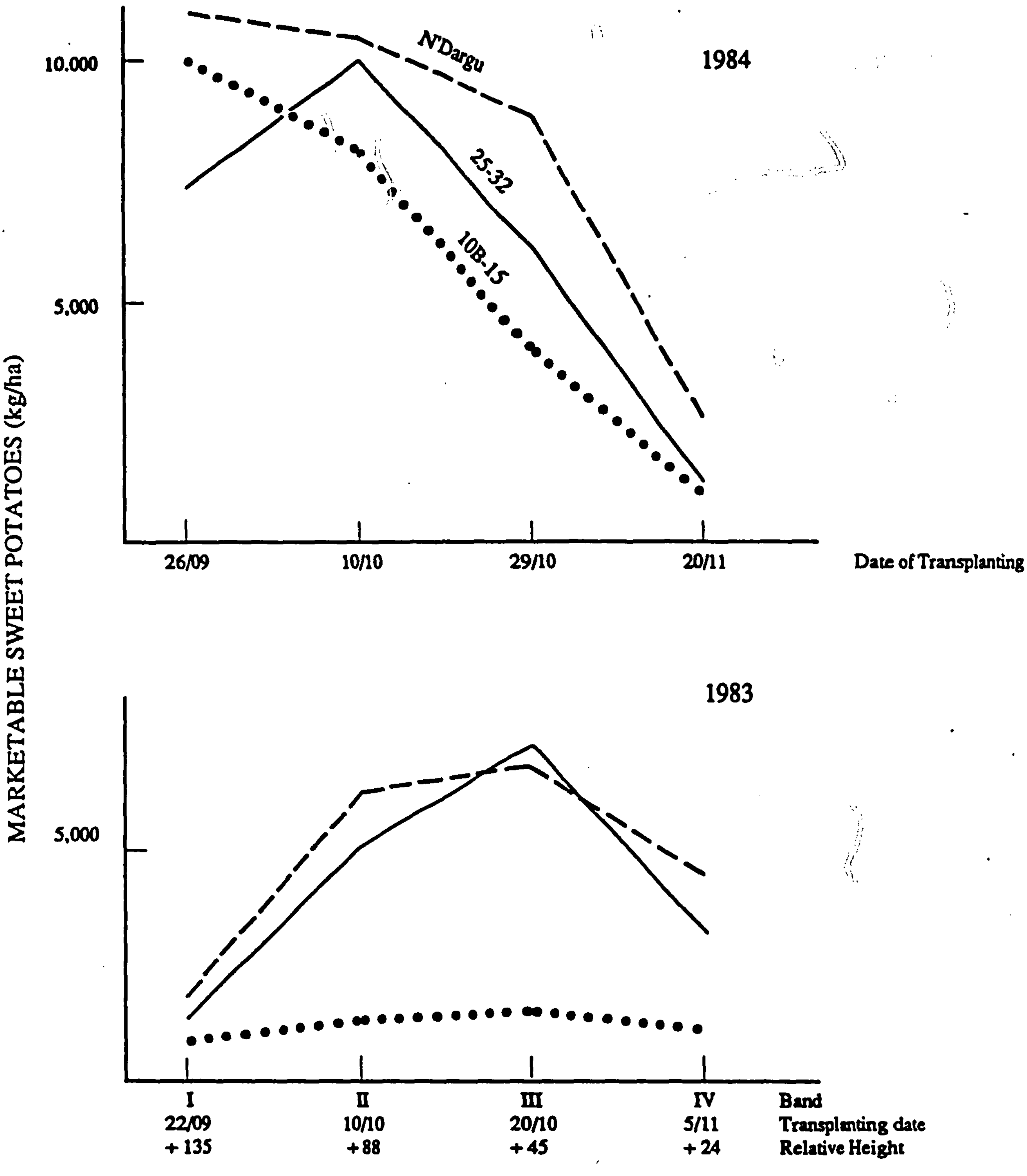


Figure 9

MARKETABLE SWEET POTATOES YIELDS (KG/HA)
TRANSPLANTED AFTER RICE-DJIBELOR STATION 1983 AND 1984

TABLE 44

MARKETABLE SWEET POTATO YIELDS (KG/HA) FOLLOWING RICE HARVEST (AVERAGE CYCLE LENGTH = 100 DAYS)

Maoua			Loudia-Ouoloff		
No. of Trials	Date of Planting	Mean Yield kg/ha	No. of Trials	Date of Planting	Mean Yield kg/ha
4	11/10/83	2478	4	03/02/84	4201
5	22/10/84	2559	5	05/02/85	5000
9	20/10/85	2535	6[a]		

[a]Six trials were initiated in early 1986 at Loudia-Ouoloff but the trials were not monitored as there was no experimental assistant in the village at the time.

major problem. They have easy access to tubers due to the dryness of the surface soil.[49] Damaged sweet potatoes which are not marketed are either eaten in the home or given to animals.

The most critical issue for the success of recessional crops is available water. At Maoua, the crop followed early maturing rice varieties. Mechanized land preparation using the ridge and furrow method permitted transplanting before the 15th of October in the case of several farmers. In contrast, at Loudia-Ouoloff where transplanting is done after aquatic rice (in February), it was necessary to water during the first two weeks after transplanting to insure that the cuttings would take.

[49]The eggs of these insects are laid in the tubers which are often found to be replete with tunnels made by the larvae.

3. Fertilizer Applications

Fertilizer tests were concentrated in the zones where we felt water stress would not immediately limit tuber yield. On high abandoned rice fields, we transplanted the tubers (variety 25-32) in mid-August (see Table 45). Check plot yields were 5.5 t/ha of marketable potatoes but yields doubled with heavy fertilization. On average, these plots received 550 mm of rain.

TABLE 45

SWEET POTATO FERTILIZER TRIALS: YIELDS FOR VARIETY 25-32 (KG/HA MARKETABLE TUBERS)

Toposequence	N	Control Without Fertilizer	100 kg/ha 8:18:27 75 kg/ha Urea	200 kg/ha 8:18:27 150 kg/ha Urea	F-Test
Upper rice fields	5	5552	8746	10819	39.37[a]
Aquatic rice fields	6	7685	8538	9116	NS

[a]Significant at 1%

NS = Not Significant

Lower down in the toposequence, at the level of the aquatic rice fields, we put in the same type of trial. Whereas sweet potato yield for the control plot was higher in these fields than in the abandoned rice fields, there was less response to fertilizer. It is not surprising that in zones where the soil is heavier and richer, the effect of fertilizer would be lessened. Also, water stress towards the end of the cycle (transplanting done in February) tends to be severe. Nevertheless, the tests indicate that recessional sweet potatoes do have a real potential in this zone.

D. Conclusions

Sweet potato culture is an interesting option for lowland areas. Our research on the periphery of the inland valleys of Djibélor indicates that there are zones (not too high or with a heavy clay surface horizon) where yields between 5 and 7 tons/ha can be achieved. On abandoned fields high in the toposequence planted in August, or aquatic rice fields still wet after harvest, modest fertilizer applications (100 kg/ha of 8:18:27 and 75 kg of urea) make it possible to obtain even higher yields, on the order of 8.5 t/ha.

PART THREE:
CONCLUSIONS AND DISCUSSION

XI. OVERVIEW

Lowlands predominate in the Ziguinchor Department of the Casamance, comprising 41% of the total area. They are still the preferred area for rice production. However, it is estimated that about 50% of the lowland rice fields have been abandoned to date. Only 20,000 ha remain under cultivation. The principal reason for the decrease in rice area is the 30% decline in rainfall over the past 20 years; in Ziguinchor, the average rainfall in 1960-64 was 1,580 mm compared to 1,100 mm in 1980-84.

Given such a dramatic climatic change, annual flooding has only infrequently been adequate to grow aquatic rice. Twenty years ago, average rainfall during the month of August was consistently above 475 mm and there was a great deal of run-off into the rice fields. In the last two decades, the average has been closer to 225 mm. This amount has not been enough to bring about the annual desalinization of the mangrove rice fields and has resulted in their being abandoned. Moreover, even the upper rice fields no longer flood regularly. In areas which are still cultivated, farmers are looking for new ways of combatting the problems engendered by the lower rainfall, namely:

- Water stress (provoking a move to direct seeding and use of short season varieties)
- iron toxicity
- salt intrusion (combatted by the construction of large scale anti-salt dams at the level of the valley).

The main observation that emerges from four years of agronomic monitoring and survey work in the Lower Casamance is that Casamance farmers cling to their traditional agricultural system while simultaneously searching for solutions to the problems created by the drought. The role of field position is fairly clear: the upper rice fields are only suitable for direct seeding while the lower, salt-affected fields must, of necessity, be reserved for transplanted rice. The rainfall pattern and the other activities of the farmers determine the appropriate method of planting the belt of rice fields between the two extremes.

The strategies used by villagers confronted with the drought are quite varied. In the traditional Diola zone (zone I) at the mouth of the river, men undertake land preparation for all crops. This system, which has its origin in the swamp rice culture of Oussouye and Guinea Bissau, is ecologically well adapted and efficient when rainfall is at least 1,500 mm and when adequate flooding occurs in the rice fields by mid-August. When men in this zone have finished preparing and weeding the upland fields, they begin tilling the rice fields. At the present time, however, transplanting is not done before the beginning of September (when about 750 mm of rain has fallen), and few rice fields become sufficiently flooded to obtain a good rice yield. Farmers enlarge or reduce the area of transplanted rice on the basis of the rainfall pattern but the alternatives are very circumscribed.

Proceeding upstream to the Blouf and the Fogny-Combo (zones II and V), the same social organization of work exists but the total area of rice fields higher in the topsequence is greater and the annual rainfall is even lower. Transplanted rice has been all but abandoned in favor of direct seeding in these zones. The efforts of PIDAC, the local extension service, have facilitated the conversion. The competing labor demands of rice and upland crops that exist within the family have been partially resolved by the introduction of animal traction. The question of which crops should have priority remains an issue, however. At Tendimane, for example, the average date of planting in the transitional rice zone was extremely divergent from one year to another: in 1982 it was as early as the 7th of July (after 106 mm of rainfall), while in 1985 it occurred as late as August 8th (after 503 mm of rain). The difference of one month (and 400 mm of rainfall) meant additional time for increasing areas in groundnut and millet.

In the East, the problems are different. The social organization of labor typical of the Mandinka prevails (zones III and IV), and thus at the beginning of the rainy season, women prepare the land for the cultivation of rice and men concentrate on upland crops. Such a system facilitates the adoption of direct seeding. In the Northeast, the driest area of the Ziguinchor Region, there are villages which have given up rice cultivation altogether for the present. There, women have begun growing sorghum, millet and groundnuts in their own fields (Diouf, 1986).

Given such a range of adaptations and constraints related to rice cultivation, the research service must conceive of a research and extension program which will offer farmers a number of viable alternatives. It is far too simplistic to recommend direct-seeded rice as the unique solution to the problem of rice farming in the Casamance as has been done in certain documents (SOMIVAC, 1982).

Furthermore, to attribute the difficulties of transferring this technology to the farmer to their being "open" or "resistant" to change (i.e., whether they have adopted direct seeding or not) reflects a fundamental lack of comprehension of the complexities of the farmer's situation.

A more constructive approach is to develop recommendations based on an understanding of the farming systems of the Casamance, particularly those revolving around rice. The recommendations proposed by the Farming Systems team in 1983 (ISRA, Annual Report 1982-3) and taken up by SOMIVAC (the regional development agency) in 1984 constitute a point of departure for the development of technological packages that are more effective and adapted to the area.

In sum, the following conclusions emerge from our research regarding the lowland areas of the Lower Casamance:

A. Traditional Diola Systems (Zones I, II and V)

In these zones, men prepare the fields for all crops grown. Since the introduction of direct-seeded rice, there is an increased demand for their labor at the beginning of the agricultural season because direct-seeded fields must be planted at the same time as those of upland crops.

1. Zone I--Oussouye

In this zone, not only is transplanting a practice firmly rooted in Diola tradition, but rainfall is higher and the rice fields lower in the toposequence than is the case elsewhere. In addition, the sandy soils and relative lack of land suitable for upland crops have made it prudent for farmers to retain transplanted rice. Any interventions must take these facts into consideration.

2. Zone V--Fogny Combo

The degree of penetration of animal traction is relatively high in this zone which has paved the way for much more rapid planting of the plateau, and consequently the possibility to convert to direct-seeded rice. The fact that it is men who carry out land preparation has clearly had an impact on the adoption of animal traction in the rice fields.

3. Zone II--The Blouf

A buffer zone, the Blouf has been an area severely affected by the drought. Rice fields are higher in the toposequence than those at Oussouye, and almost as sandy. Rainfall in the area has been extremely low, however. Farmers do not have the option of using animal traction, nor are there adequate upland fields that can be annexed as has been done in the Fogny-Combo. A transition to direct seeding is critical but will be difficult for this area.

B. "Mandinguized" Diola Systems (Zones III and IV)

Rice production in this area is completely in the hands of women. With the decrease in rainfall, women have moved from transplanted to direct-seeded rice with few problems. However, the sexual division of labor practiced here discourages mechanization, which permits the intensification of rice production. In order to use animal traction, which is available in the area, women must wait for men to finish planting the plateau crops. Only then will they consent to plow their wives' fields. In addition, under this system of labor, the cost of fertilizer and other inputs for rice production are womens' responsibility, although according to tradition, women are not supposed to sell rice as it is the cornerstone of the family diet. Thus, the cash needed for inputs must come from another source.

1. Zone III--Niaguis

A semi-urban area surrounding Ziguinchor on the east with broken topography, good rainfall and heavy textured soils. The ethnic mix (Mancagne, Manjaque, Bainouk, Diola, Mandingue and Balante) and proximity to Ziguinchor confer a host of possibilities. Among them is the potential for adopting modern techniques (tractors, fertilizers, herbicides, etc.) for rice cultivation, the introduction of animal traction for producing upland crops (maize, cowpeas, manioc) and the intensification of vegetable gardening during the dry season.

2. Zone IV--Kalounayes

In this area, the lack of inputs is a major constraint. Direct-seeded rice yields are good, and the women are known to be very diligent and hard working. The dissemination of a modest input package would be profitable, at least in the wetter, southern zone.

XII. IMPROVED LOWLAND CROPPING SYSTEMS: RECOMMENDATIONS FOR RESEARCH AND EXTENSION

A. Varieties

Casamance farmers are looking for shorter cycle varieties. Local varieties such as Barafita (90 days), Abdoulaye Mano (120 days) and Senicoly (120 days) are good and are well represented across the transitional zone. In the aquatic rice areas, however, each village has its own local variety.

In the transitional zone, the varieties recommended by the research service are more productive than the local varieties (see Variety Trials). Moreover, they are quite hardy, even when cultivated under difficult conditions. Currently, PIDAC recommends 144B/9, a good rainfed variety which adapts well to the more humid conditions in the phreatic zones. The results of our trials under farmers' conditions do not permit us to recommend that IRAT 133 or DJ-12-519 replace 144B/9. Nevertheless, we think it is important at this point to initiate a multilocational trial of these three varieties in order to better determine their respective ecological niches. PIDAC's bureau of "Recherche d'Accompagnement" is in the best position to supervise this effort. Our results show clearly that DJ-12-519 is particularly well adapted to the most humid rice growing areas.

In the aquatic zone, the situation is less clear. Late rains and iron toxicity in many of the rice fields impose constraints which are difficult to tackle by varietal selection. In the zones where salt intrusion is a major problem, the period of desalinization (saturated paste < 5 mmhos/cm^2) is often too short for a successful rice crop. There is only a very narrow band of aquatic fields remaining for which the use of improved varieties would be possible. Since there is very little fertilizer used for this type of rice culture, indigenous varieties are still well suited to the area. For all the above reasons, it is our opinion that the emphasis in the aquatic zone should be first and foremost on improving the physical environment (i.e., building retention dikes and drainage ditches). When the aquatic milieu is brought under better control, the varietal issue can be addressed. In fact, considerable knowledge in this domain is already available. Two varieties adapted to acid soils (Rok 5 and DJ 648D) and two suited to better rice plains (IR-8 or IR-442) are being promoted and used.

B. Fertilizer Use in Rice Production

Diola women have always fertilized their best rice fields with organic matter. With the exception of the aquatic rice zone in Oussouye, this practice is less and less common because of the drought and the introduction of chemical fertilizer.

In the transitional rice growing areas, the use of chemical fertilizer has grown considerably. Our results from farmers' plots in 1984 and 1985 indicate that there has been an increase in yield from 2.5 kg/ha of paddy for every kilo of complete fertilizer used (8:18:27) and 3.5 kg/ha of paddy for each kilo of urea. In our trials, we found that for rice fields with silty clay soils or heavier, having a pH > 4, the following response curve resulted: $y = 6.27x - .008x^2$ (x = kg of 8:18:27 + urea in the proportion of 1:0.75; $R^2 = 0.37$).

On these better fields, yields were rarely under 3 tons/ha, which suggests that we should be able to aim conservatively for yields of 2.5 tons/ha of paddy. We recommend 100 kg/ha of 8:18:27 at planting and 75 kg/ha of urea at weeding (at about 30 days after planting). Using this dose, our trials yielded 2.4 tons/ha on average.

For rice fields on lighter soils which are more acid and often have less available water, we found many constraints which make the response to fertilizer less uniform. In particular, problems due to emergence (soil insects), iron toxicity, drought stress and a lack of trace elements (especially zinc) have often made fertilizer trials difficult to interpret. To better define the types of rice fields which are best suited to direct seeding and the use of fertilizers, we propose that ISRA and PIDAC initiate a joint program of research. Fertilizer trials conducted on typical rice fields in many villages would permit researchers to more finely tune technical packages being proposed to specific types of rice fields.

C. Mode of Planting

Given the current rainfall deficit, direct-seeded rice remains our recommendation, despite the manpower problem it creates for men who also farm the plateau. In addition to the labor constraint, soil fertility becomes an issue when direct seeding is employed. The traditional Diola zones (I, II and V) are situated on the coast of the Lower Casamance where sandy fields are most common. In the fertilizer and mode of planting trials, we identified a number of constraints which are linked to the nature of these fields. Our results show that direct-seeded rice on the high sandy rice fields requires substantial additions of organic matter, as well as the use of insecticides and short cycle varieties. Even so, as long as the rainfall remains low, direct seeding will continue to be adopted by Casamance farmers. The problems mentioned above are not as important for direct-seeded rice in the heavier fields further toward the east.

For direct seeding to be successful in these zones also demands that other problems be taken into account. The system used by PIDAC, which involves working with farmers who are organized into cooperative groups in the most productive valleys in the region, is promising. However, it is important to coordinate direct seeding with the other preoccupations that farmers have on the plateau. With this objective in mind, we recommend that farmers first plant corn and a part of their groundnut and millet crop before initiating work in the rice fields. Then, after two weeks' work in the rice fields (from about the 7th to the 21st of July) they can return to the plateau to continue their work with groundnuts, sorghum and millet. Obviously, the rice fields which are the wettest should be left for later transplanting (near the end of August). This type of calendar will become more possible if animal traction becomes well established in the Diola zones, and if men in the "mandinguized" areas begin considering rice production more than solely a woman's task.

D. Weed Control

One of the principal constraints for farmers throughout the region is the lack of farm labor at crucial periods. Their hesitancy in abandoning transplanted rice--a crop that does not require weeding--is therefore understandable. For direct-seeded rice, we have shown that ridge tilling reduces the time required for weeding without affecting yields. Therefore, PIDAC's recommendation, that farmers in their cooperative groups flat till, should be amended. If it were possible to mechanize direct-seeded rice (either by seeding with oxen or with a hand seeder) as Havard (1985) and Fall (1986) have demonstrated, flat tilling would then become commonplace because it would be profitable. In both the seeding and herbicide trials, row seeding was found to facilitate weeding. Thus mechanized row seeding should be one of the principal extension themes in the future.

In addition to seeders, the use of herbicides was shown to be quite worthwhile for growing rice in the Lower Casamance (Herbicide Trial). Herbicides help prevent weeds thereby increasing yields, allowing in good years for an increase in the area of rice planted. Financial credit for farmers, which is presently limited to equipment and fertilizer, should be expanded to include herbicides (Ronstar, Tamariz). Moreover, the potential for mechanical weeding in fields already planted in rows should be examined by the research service.

E. Diversification in the Rice Producing Areas

In an attempt to increase production in the lowlands of the Casamance, we carried out trials with maize and sweet potatoes in the abandoned upper rice fields as well as sweet potatoes grown immediately after the rice harvest in the lower fields. Results indicate that sweet potatoes transplanted in August can produce between 5 and 10 tons/ha of marketable tubers. Maize yields on the other hand were very unstable.

Sweet potato yields, after phreatic rice, were 5 to 7 tons/ha on the station and 2.5 tons/ha on farmers' fields. Grown after aquatic rice, sweet potatoes yielded 4.5 tons/ha of marketable tubers. The introduction of this crop grown after rice or in abandoned rice fields is limited to areas where soils are not too heavy. In addition, it requires ridge and furrow tillage. At the present time, Ndargu, a red skinned sweet potato, is the most productive variety.

XIII. CLASSIFICATION SCHEME FOR RICE FIELDS IN THE LOWER CASAMANCE

As a means of summarizing the numerous conclusions of this research, a classification of the type of rice fields encountered in the region is proposed. The classification takes into account scientific criteria regarding both changing climatic conditions and diverse soil types while emphasizing the practical viewpoint of the farmer. The system is offered as a means of facilitating what should be an on-going three-way dialogue between the farmer, the extension service and the research service.

The first criterion employed in the classification is the farmer's mode of planting. There are two options: direct-seeded rice which is begun in early July (mode 1); and transplanted rice, done in the beginning of September (mode 2). All other aspects of production hinge on this choice. Thus, the issues of land preparation, insect and weed control, nutrient deficiencies and the variety of rice grown are determined to a large extent by the way that the field is to be planted. As a point of focus, mode of planting is a much more practical criteria than water regime. One reason for this is the depth or duration of submersion of a plot has been virtually impossible to predict since the onset of the drought. However, in several zones, after having considered all their responsibilities, farmers are able to determine how many fields will be direct-seeded and how many will be transplanted, if the conditions permit.

The second criterion is the position of the field in the toposequence. Three places have been identified in our system: the plateau (.1), the inland valleys (.2), and the alluvial plains (.3). Direct seeding is carried out in all three areas with varieties of differing cycle lengths. Transplanting is limited to the stream beds of certain inland valleys and to the alluvial plains.

The third criterion is a qualifier for the toposequence position. On the plateau where the soils are largely sandy loams on the surface, the degree of organic matter and the degree to which the field is weed free distinguishes "pam-pam" rice (1.1a) areas (recently cleared) and fields where rice is in rotation (1.1b) with other crops. In the inland valleys, the texture of the soil is the determining factor. The valley sides are quite sandy (1.2a) whereas the stream beds have a very heavy texture (1.2b). On the flood plains the shallow flooded areas (a) are distinguished from the deep flooded areas (b). The potential for rice production is tied to the position of the field on the one hand (with the concomitant problems of salinity, acidity, water stress and iron toxicity), and the texture of the soil on the other (contributing to mineral deficiencies and iron toxicity).

A schematic diagram of the toposequence of Lower Casamance is presented in Figure 10 with the determinants of the classification system indicated below it. The broadest categories follow.

A. Direct-Seeded Rice

1. Upland "Pam-pam" Rice (1.1a)

After a fallow farmers clear the land and put in a rice crop for one or two years. The system benefits from the accumulation of organic matter and the absence of weeds (common in Boukitingo and Bandjikaki).

2. Upland Rice in Rotations (1.1b)

Deep plowing, row planting, the use of short cycle varieties, fertilizers and good weed control are crucial inputs to this mode of growing upland rice. This type of production is rarely practiced in Lower Casamance.

3. Direct-Seeded Rice Along the Sides of the Inland Valleys (1.2a)

Rainfed rice is grown in palm groves along the inland valleys. Soils are generally poor in these zones but with the use of fertilizer and good weed control, adequate productivity is possible (the high areas of Medieg and Kature). The sandy upper reaches of the valleys are, however, less responsive to inputs (Suel, Toukara).

4. Direct-Seeded Rice at the Bottom of the Inland Valleys (1.2b)

The heavy soils of these fields which are well supplied with water make inland valley bottoms very productive areas for direct-seeded rice (Kature, Medieg).

5. Direct-Seeded Rice on the Shallow Alluvial Plain (1.3a)

In certain areas of the flood plains especially where the soils are heavy, direct seeding can be successfully accomplished without difficulty (Boulandor, Boulom). The transition to direct seeding, however, has not been easy on the older sandy rice terraces and in some fields where soils are very

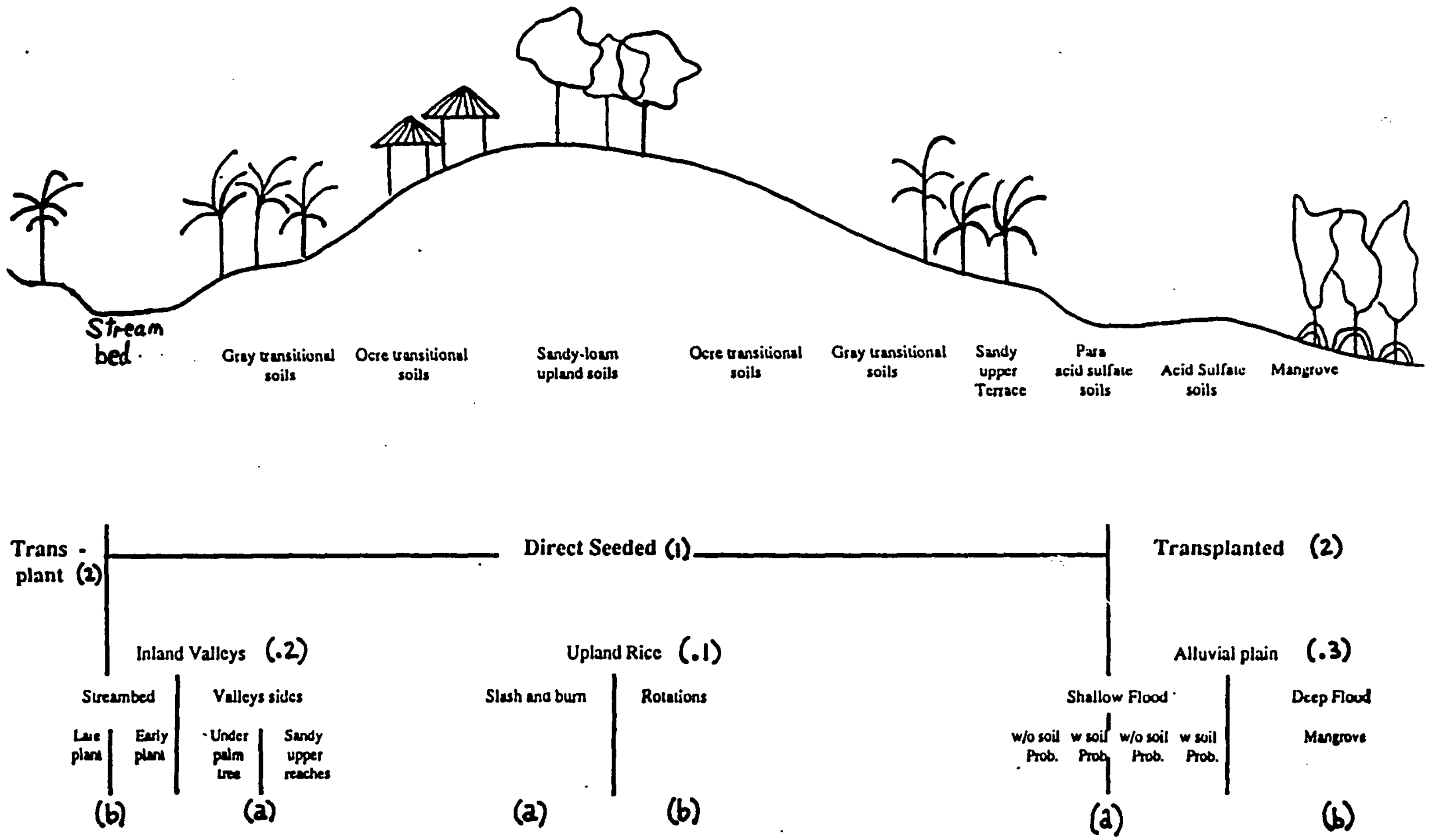


Figure 10

PROPOSED CLASSIFICATION SYSTEM FOR RICE FIELDS IN THE LOWER CASAMANCE

acid. In these zones, considerable additions of organic matter are required (Tendimane, Mahamouda).

B. Transplanted Rice

1. Transplanted Rice in the Inland Valley Bottom (2.2b)

In certain inland valleys, along the streambed, farmers transplant rather than direct seed rice once the area is submerged (Medieg, Kature).

2. Transplcnted Rice on the Shallow Alluvial Plain (2.3a)

In a large area, traditional transplanted rice grows quite well. The area will expand with the construction of anti-salt dams in the region (Seleky, Boukitingo). Nevertheless, salt intrusion and drought stress have been problems in other areas. To some extent these problems can be resolved by using short cycle varieties. Iron toxicity or a low pH are more difficult to overcome, however (Bandjikaki, Loudia-Ouoloff).

3. Transplanted Mangrove Rice (2.3b)

This zone, which was cultivated in previous years, has been virtually abandoned today. The river water is fresh for only two or three weeks at the end of the season (Maoua, Loudia-Ouoloff).

C. Conclusions

Researchers continue to refine the categorization of rice growing systems in the Casamance and this will help them identify better techniques for production. Once we are able to recommend practices that are both technically valid and fit into the existing farming systems we will have accomplished our objective of developing a range of alternative ways to increase production in the lowlands areas of the Casamance.

APPENDICES

APPENDIX 1

NUMBER OF RICE PLOTS OBSERVED IN THE AGRONOMIC SURVEYS
BY VILLAGE (1982-1985)

		Aquatic Rice				Transitional Zone Rice			
Zone	Village	1982[a]	1983[a]	1984[a]	1985[b]	1982[a]	1983[a]	1984[a]	1985[b]
I	Loudia-O.	26	25	23	25	0	0	0	4
	Boukitingo	49	53	57	22	0	1	0	0
	Mangagoulak	138	NM	NM	NM	1	NM	NM	NM
	Seleky	NM	NM	NM	86	NM	NM	NM	17
II	Mahamouda	23	17	29	NM	0	17	10	NM
	Tendimane	2	0	0	17	84	28	31	4
III	Boulom	68	47	35	NM	30	36	81	NM
	Maoua	14	9	20	10	68	60	47	28
IV	Boulandor	18	4	10	13	115	64	89	30
	Medieg	27	30	6	NM	98	53	80	NM
	Toukara	NM	NM	NM	0	NM	NM	NM	17
V	Bankjikaki	34	11	1	18	0	1	4	8
	Suel	NM	1	5	2	NM	30	38	13
Total plots		399	197	186	193	365	290	380	122
Area (ha)		67.6	36.3	37.9	13.7	58.3	58.3	45.6	10.4

[a]From 82-4, 125 farms were monitored.

[b]In 1985, 35 farms were monitored.

NM = Not monitored.

APPENDIX 2

AVERAGE SIZE OF PLOTS MONITORED (ARES) AQUATIC (A) AND TRANSITIONAL ZONE RICE (B)

A. Aquatic Rice

Village	1982	1983	1984	1985
Loudia-Ouoloff	51	40	45	39
Boukitingo	14	16	18	17
Seleky	-	-	-	8
Mahamouda	20	22	26	NM
Boulom	16	11	13	NM
Maoua	20	15	17	10
Medieg	12	8	-	NM
Bandjikaki	62	49	-	54

B. Transitional Zone Rice

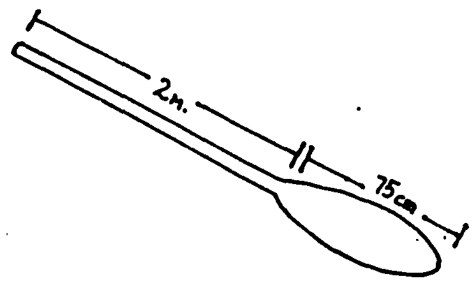
Village	1982	1983	1984	1985
Mahamouda	-	6	6	NM
Tendimane	21	16	18	28
Boulom	17	10	9	NM
Maoua	22	14	18	11
Boulandor	9	9	10	9
Medieg	10	10	10	NM
Suel	NM	20	15	16
Toukara	NM	NM	NM	30

NM = Not monitored

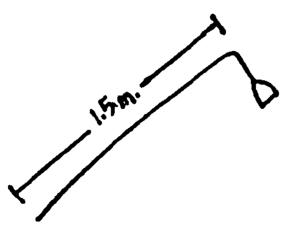
APPENDIX 3

PRINCIPAL LAND PREPARATION TOOLS USED IN THE LOWER CASAMANCE.

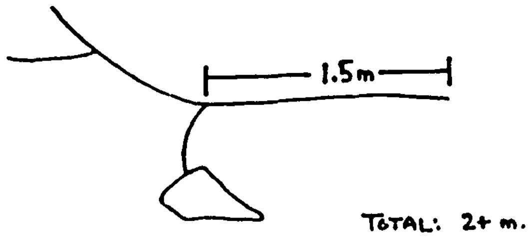
A) Cayendo



B) Fanting



C) UCF Plow



APPENDIX 4

THE MOST COMMON RICE VARIETIES IN THE STUDY VILLAGES

Village	Varieties
Loudia-Ouoloff	Senicoly N[a] - Ebandoulai R[b] - Gheghene T[c] Ebigne R - Abdoulaye mano N - Yahitai R - Rok5 N
Boukitingo	Elansana R - Ekouly R - Mpak R - Kaghoye T
Seleky	Essoboro rouge T - Ehog T - Essoboro blanc T Etouhal[d] T
Maoua	Mere mano R - Coubone R - Yaya Ba R - Bassite N Richard-Toll R - Loumbene R - Barafita R - Bilikissa R
Boulandor	Barafita R - Chinois yaya R - Ndiama R - Pekin N Senecoly N - Barafita R - DJ-12-519 N - 144B/9 N
Medieg	Bassite T - Barafita R - Diamisse T - Ndiama R
Tendimane	Senicoly R - Bilikissa R - Abdoulaye mano R
Bandjikaki	Barafita R - Assekayi R - Sefa R - Bindoum T
Suel	Abdoulaye mano R - Manodj N - 144B/9 N
Toukara	A. Toumpaye R - Tangal R - Abdoulaye Yemaye R

[a]N = New - grown in the village less than 5 years

[b]R = Recent - grown in the village between 5-20 years

[c]T = Traditional - grown for at least 20 years

[d] = Species is Glaberrima

APPENDIX 5

SPECIFIC PROBLEMS AFFECTING RICE YIELDS IN THE AQUATIC ZONE

	kg/ha of paddy		
Problem cited	1983	1984	1985
None	927	927	1,416
Water stress	570	593	339
Salt toxicity	451	500	450
Iron toxicity	431	419	595
Acidic soils	278	278	265

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