Rehabilitation of rice fields in the acid sulphate soils of Lower Casamance, Senegal

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Abstract

The Casamance region in the south of Senegal is historically a region of rice production for home supply. Since the recent drought, the production stagnated while an increased population demands more and more rice imports.

Since the seventies, the government has taken measures to increase the degree of self-sufficiency in rice. Among these, the development of 'mangrove rice' production with the construction of dams is one of the most important. During the very dry years in the beginning of the eighties, the main objectives were to protect the ricefields from salinization and to rehabilitate the areas of acid sulphate soils. The anti-salt dams did not increase rice production.

A 150 ha polder in the small valley of Djiguinoum, directly in connection to the Casamance river, was chosen to try a new water management system. Sluices allow drainage of salts and acids at the beginning of the rainy season and, also, maintain water for rice culture.

Three fields on a degraded area (about 1 ha) were equipped with an outer dike and a drainage network connected to the main river. Traditional techniques, used by the farmers, were applied for the rice cultivation. During two consecutive years a significant increase in yield was obtained. In the first year, salt movement in the soil was controlled by the dam. In the second year ploughing, tolerant varieties and fertilization were also tested.

A social inquiry was held, investigating whether the rice culture actually had any chance to become again a main interest for the population.

Introduction

The effects of the recent droughts are now well known in lower Casamance, especially in the mangrove environment (Marius 1979, Marius et al. 1986; Boivin et al. 1986, Loyer et al. 1988, Pages and Debenay 1987, Pages et al. 1987, Le Brusq et al. 1987, Dacosta 1989, Montoroi 1990, Mougenot et al. 1990). The principal consequences are:

- Decrease and destruction of the mangrove vegetation;
- Increasing salinity in coastal waters;
- Chemical degradation of lowland soils;
- Decreasing rice production, increasing activities in the uplands;
- Increased erosion in the uplands;
- Migration to the cities.

The Casamance region is historically occupied by a population of farmers and fishermen, the Diolas. Rice is the staple crop. Rice cultivation has a dominant role in Diola society, although drought and migration have diminished it. The stagnation of rice production means shortage at the end of long dry seasons but more-rewarding crops, like peanuts, can pay for imported rice.

Management of the 'mangrove soils' is an old custom in this region and water management is well-adapted to conditions of normal rainfall (Pelissier 1966). However, with the dramatic decrease in rainfall (Figure 1), soils have become very saline and severely acid.

The government wanted to develop rice production, especially in the mangrove area, because national self-sufficiency dropped from 40 per cent in 1970 to 20 per cent in 1984. To this end, the construction of dams across the main branches of the Casamance river has been studied. The aim was to protect the mangrove forest and to adapt the water management to the soils; for example, to avoid acifidication during the dry season.

During the very dry years at the beginning of the eighties, the high levels of salinity in the rivers made it necessary to revise the water management.

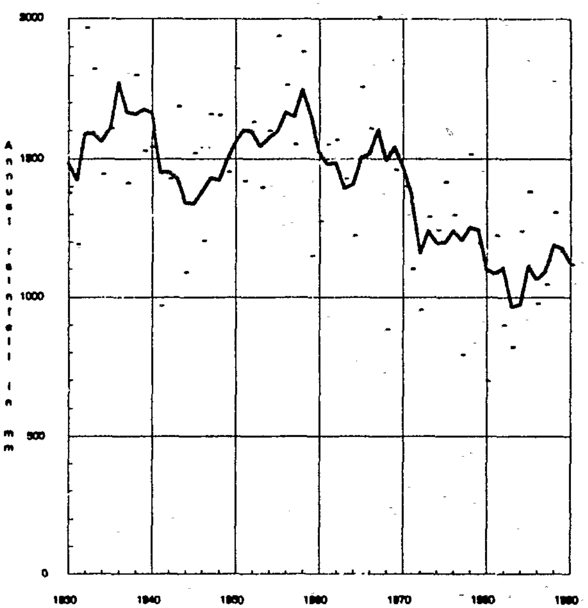

Figure 1 Annual rainfall in Ziguinchor during the period 1930-1990
Full line: five year averages
Dotted lines: average annual value for twenty year periods:
1931-1950: 1541 mm; 1951-1970: 1524 mm;
1971-1990: 1133 mm

It was necessary to protect the rice fields from salinization. The construction of small, anti-salt dams with a water control structure, hand-made by the people, was externally supported (USAID/SOMIVAC/ISRA 1985). Some of these dams have been effective, especially in the sandy valleys, but not in other cases. The rice production was lower than planned.

Some technical solutions for the reclamation of acid sulphate soils were tested in Casamance before the drought (Beye 1973a,b, 1974, 1977, Beye et al. 1978). Here the results of a field experiment in the Djiguinoum valley are presented. The sluice of the anti-salt dam has been improved to facilitate the water management and different culture techniques have been tried in rice fields.

Environmental situation

The Djiguinoum valley is located on the right bank of the Casamance river, 15 km northeast of Ziguinchor. The catchment has a surface of 26 km^2 (Figure 2). The anti-salt dam is situated near Djilakoun. 150 ha is flooded in the rainy season. The field experiment is situated near the Ziguinchor track, about 1 km north of the dam, on an acid sulphate soil.

The surface horizon is well-structured; the clay content was between 70 and 75 per cent with a silt fraction of 20 per cent. pH value was 3.5 for the surface horizon and 2.5 at depth; exchangeable aluminium was 40 mmol kg^{-1}; total sulphur 3-5 per cent by mass in the subsoil. The groundwater level was at 1.2-1.4 m at the end of the dry season with a pH of 4, an EC of 16 dS m^{-1} and high soluble aluminium (0.6 mmol l^{-1}). Salts are observed on the surface and form a weak crust mixed with clay in some places.

The red soils of the surrounding uplands support forest and peanut culture.

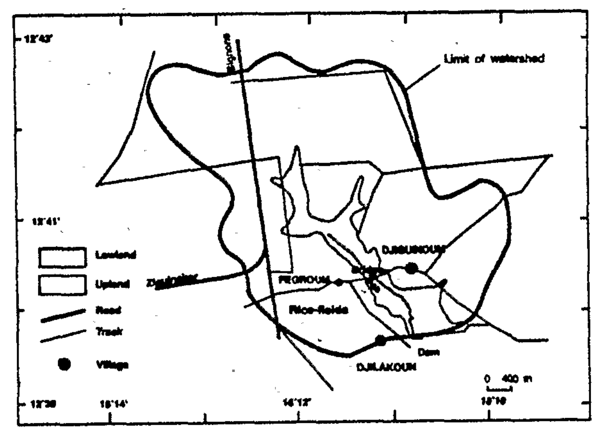

Figure 2 Field experiment site in the catchment of Djiguinoum

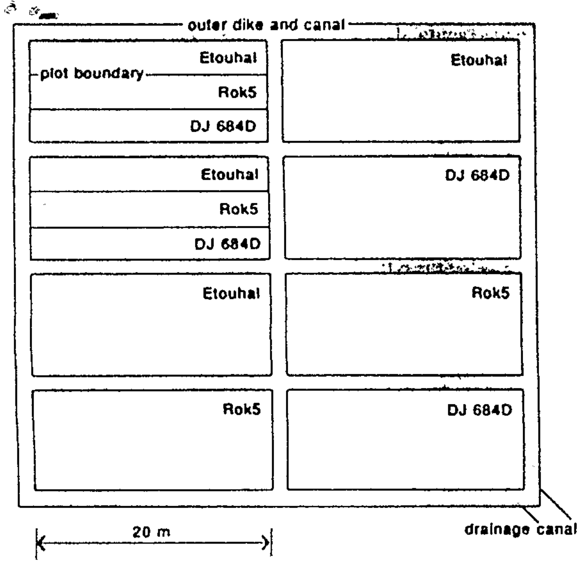

Figure 3 Traditional rice field with salt-tolerant varieties used in 1990. The two rice-plots divided in three strips are not ploughed before plantation time. No fertilization.

Methods

Water management

The original sluice was made of wooden boards and regulating the water level was hard when the upstream side was full of water. A new system, installed in 1988, consists of manually-operated vertical slide gates (Albergel et al. 1990). Four rules are applied at the anti-salt dam to improve the water management:

- Wash out the first runoff, which contains a high level of salts, at the beginning of the rainy season;
- Maintain an appropriate water level for rice during the wet season;
- Avoid flooding of the track crossing the valley;
- Open the sluices when the upstream level is at least 4 cm higher than the downstream level.

Field experiment

A traditional field (Figure 3) and an hexagonal field (Figure 4) were constructed with a local tool, the 'kayendo' (Marzouk-Schmitz 1988). The traditional rice field has eight plots each 20 m by 10 m separated by drainage canals. A surrounding canal allows drainage to the river. In 1990, two plots were divided into three strips and left untilled. The others were tilled. Three salt-tolerant varieties were tested.

Each of two hexagonal rice fields was divided in three lozenge-shaped plots which

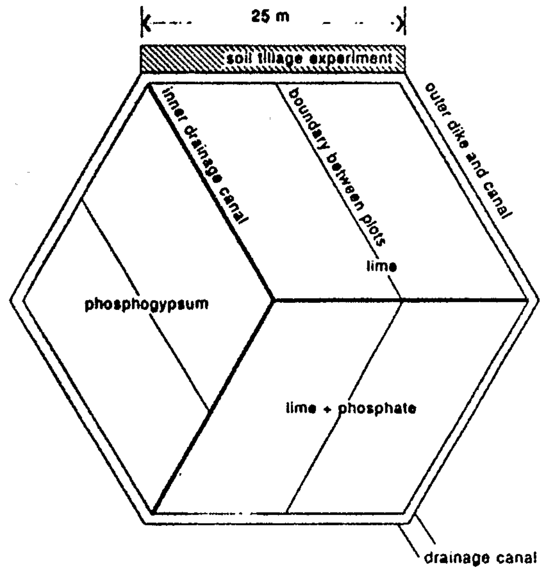

Figure 4 Hexagonal rice field with different fertilizer treatments

received different fertilizer treatments (lime, lime plus phosphate, and phosphate plus gypsum) for only one rice variety (Rok 5). The cultivated surface of this rice field was 1875 m². For the second hexagonal field, fertilizers were mixed with rice straw. The rice was transplanted into flooded fields in August and harvested in December. The chemical composition of the drainage water in tilled plots was monitored. The soil solution was extracted every week with in-situ water samplers installed at different depths. A rainfall simulator was used on a bare and a tilled soil to observe runoff and salt movements.

Results

Water management

The variations of upstream and downstream water levels are shown in Figure 5.

Effect of water management on soil salinity

Water management by the anti-salt dam diminishes the salt level in the topsoil (Figure 6). The electrical conductivity at 25 cm depth decreased from 30 to 10 dS m^{-1} in 1990. Salinity increased rapidly at the end of the rainy period. The salt profile is always increasing with depth, even during the flooded period.

At depth, the groundwater salinity remains high all year, showing a sharp increase of the salt profile in the wet season. The lowest salt level in the surface water is about

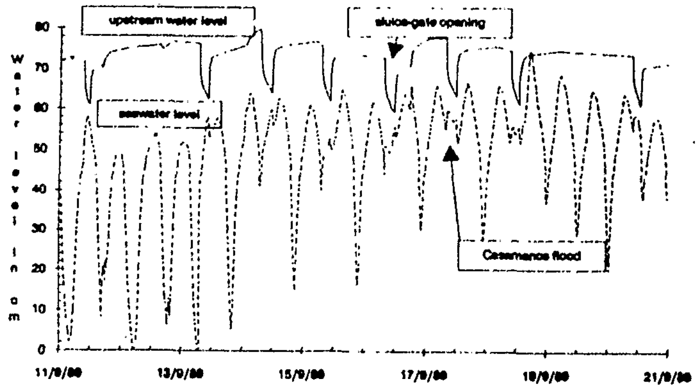

Figure 5 Upstream and downstream water levels at the anti-salt dam of Djilakoun in September 1989

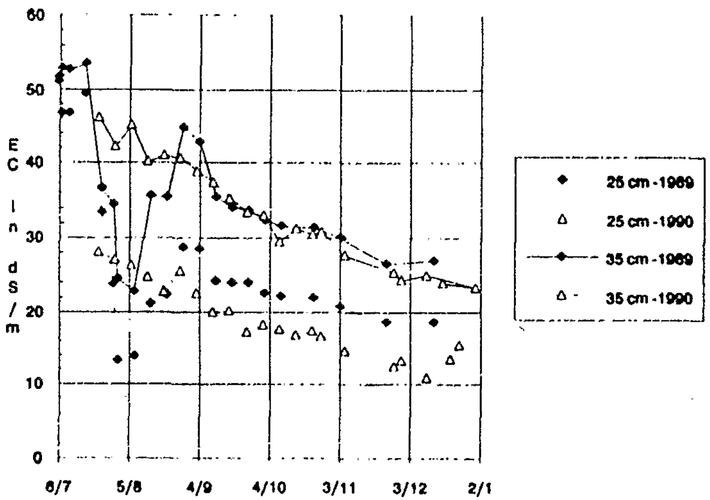

Figure 6 Effect of water management on the electrical conductivity (EC, in dS m⁻¹) of a cultivated acid sulphate soil in the Djiguinoum valley over two rainy seasons

3 dS m⁻¹ (Table 1). Rice roots grow only in the upper few centimetres, being unable to tolerate the salinity below.

Redistribution of salts

Tillage helps to decrease the salt content in the surface soil (Figure 7). On bare soil, the rainfall runs off, a salt crust is formed after each shower and infiltration is not effective.

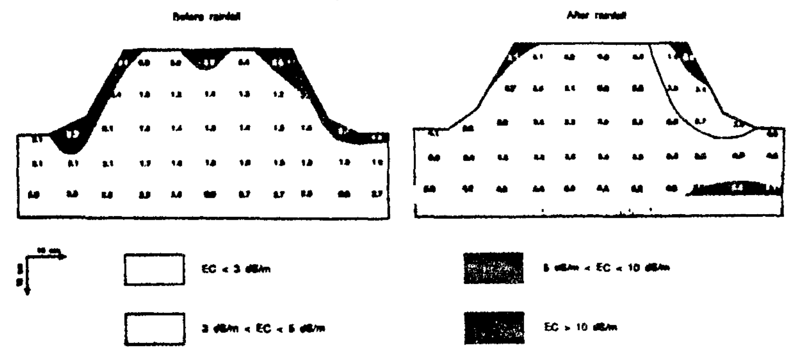

Figure 7 Redistribution of salts in a cross-section of a tilled plot after three simulated rainshowers (60 mm during one hour for each shower)

Rice production

The yields obtained in 1989 and 1990 were higher than the average yield of the Casamance region (about 1 t ha⁻¹). The results for the traditional rice field were better in 1989 than in 1990 (Table 2). The rainy season pattern was different and the water management had to be adapted. The salinity decrease was less effective. The lower yields obtained in the hexagonal rice field (Table 3) may be explained by a different planting density (125 000 plants per ha against 200 000 for the traditional rice field).

Table 1 Chemical composition of the surface water on 16 September 1989 (Brunet and Zante 1990)

pH	EC (dS/m)	Soluble ions, mmol per litre								
		Na	K	Ca	Mg	Cl	SO4	Al	Fe	Si
3.6	3.1	2.1	0.7	0.85	2.25	21	3.65	0.2	0.001	0.07

Table 2 Average paddy rice yield (in t/ha) for different, salt-tolerant varieties of rice and tillage in the traditional rice field (Brunet and Zante 1990, Brunet et al. 1991)

	Rice variety	1989	1990
Tillage	ROCK 5	2.8	2.8
	DJ 684 D	2.6	1.0
	ETHOUHAL	2.8	1.9
No tillage	ROCK 5		2.2
	DJ 684 D		0.8
	ETHOUHAL		2.1

Table 3 average paddy rice yield (in t ha [1]) for different type of fertilizers in the hexagonal ricefield (Dobos et al. 1991)

Treatment plot	Yield
A lime	1.0
B lime + phosphate	1.2
C phosphate + gypsum	0.7
Reference	0.5

Conclusion

The levels of rice production obtained in the experimental plots must be regarded with some caution. Several problems must be solved before regional extension can be advocated. Two successful years is a good basis but, in Casamance, each valley has a particular configuration and the techniques must be adapted to each case. Knowledge of the environmental conditions is required: for example, a hydrological study is needed as a basis for dam design and construction.

A major problem of water management is that all users depend on the water level control at the dam. The risk of conflicts between users is high because they cannot regulate individually, and users must be trained in the operation and maintainance of the dam. New management schemes will be needed to reclaim all the fields in a valley, for example with intermediate sluices.

The field experiment in the Djiguinoum valley has stimulated the local population to struggle against the effects of the drought on their fields. They want to come back to the valley with the desire to copy the management model used by the project (Sall 1991). An organizational structure will be essential to develop the whole valley. Socio-economic conditions have changed in the Casamance and future projects should consider this reality.

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