

Soil Nutrients and Fertilization in Irrigated Rice in the Sahel

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

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

WARDA Irrigated Rice Program Leader Kouamé Miézan explains: “At WARDA, we recognize that there is no single solution to the problems facing rice production

that is applicable to all farmers whatever their economic status, but we do recognize the need to help all farmers to make the most of their land. Soil fertility and fertilizer management in irrigated rice have been a major concern of the research efforts at our Sahel Station in Saint Louis, Senegal since 1995. Our efforts currently focus on four Sahelian countries, namely, Burkina Faso, Mali, Mauritania and Senegal. The starting signal for this particular collaboration was given during a workshop in June 1995 at the Sahel Station, where national rice scientists from Burkina Faso, Mali and Senegal identified soil fertility management as a major problem in irrigated rice production.”

There are existing recommendations for fertilizer use in irrigated rice, but these are general, and take no account of soil type, rice variety or season. “Our premise in starting this work,” WARDA agronomist Marco Wopereis elaborates, “was that a blanket recommendation is unlikely to be best suited to all situations and that fine-tuning of the

recommendations to specific soil types and farming conditions should improve both productivity and profitability.” Compare this with the current trend in farming in a country like the United States. There farming has become a precise science—fertilizer requirements are determined on a square-meter basis! West Africa may be a long way from this kind of detailed analysis, but we can at least improve our recommendations to farmers on the basis of where they are and what kind of soil they have to work with. Stephan Häfele, a PhD student from the University of Hamburg working on soil fertility at the WARDA Sahel Station, adds “As a further incentive for us to look at soil fertility, we had also noted a trend toward decreased yield over time in long-term trials established on the WARDA research station, despite these trials having received the standard recommended levels of fertilizer each year.”

WARDA cannot possibly hope to reach, let alone work with, all the farmers in the region on its own—in 1998 there were 30,000 ha of irrigated rice in Senegal alone! “The method we have adopted,” explains Marco, “is to team up with a broad range of partners. Each partner contributes to the overall goal, and benefits from the presence of the other partners—the impact of the partnership is greater than the sum of the impacts of the individual parts. We want the research to gain momentum so that its results spread to as many farmers in the region as possible.”

So, who are these partners? First, as a regional research and development institution WARDA cannot, and will not, conduct research in isolation from the national agricultural research institutions, whose partnership—that is, membership—is central to the Association. Second, we need access to a delivery system and to the farmers themselves; this is the role of the extension services, so their partnership is essential. The farmers of the region are mostly organized into ‘unions,’ cooperatives and other groups, which are fora for farmers to learn,



Partnership with extension (here AGETA in Mauritania) is essential in working with farmers in the Senegal River Valley

discuss and generally cooperate to improve their collective skill, efficiency and profit. These groups are ideal contact points for disseminating research results and identifying progressive farmers to be involved in the research process itself. Finally, WARDA collaborates with a number of development-oriented projects and non-governmental organizations.

This is what we do...

Surveys and socioeconomic studies are conducted to test the farmers’ knowledge of rice cropping in general, and their ability to plan and carry out the activities required. First, they are asked to develop a calendar of events—when will they sow; when will they transplant the rice seedlings; what fertilizer will they apply, when and how; and so on. Next, we maintain close contact and monitor farmers’ progress throughout the season—what they actually do—through numerous discussions in the field with the farmer and the extension agents. These meetings give the farmer the opportunity to discuss the crop performance with the extension agents and researchers, and the researchers and extension agents the possibility to discuss

Women Farmers' Cooperative

Zairabul Mint Ahmed is President of the Women's Cooperative Mushra Cidi farm. She and her colleagues are subsistence farmers—their entire income comes from the rice crop. "The Cooperative was formed in 1988," she explains. "The first phase was good: the government agencies gave us credit and we subsisted OK. Later a disease wiped out one year's crop; soon after that, the credit was withdrawn"—two catastrophic events in short succession! "Without credit, we stopped using machinery, we did everything by hand, and we got good results!" The rice crop became the source of everything for these women—everyone was involved in the farming, so there was no-one available to work in the towns to earn extra money. In 1998, WARDA and AGETA came to the Cooperative with a proposal to establish their demonstration plots. Four volunteers planted a single plot each for the demonstration—no-one had enough land to grow the full four-plot trial! "The full treatment plot was the best," explains Zairabul, "both in terms of yield and grain quality." This treatment—application of fertilizers and weed control—gave 5.7 tonnes of grain per hectare. The farmers' normal practice—which involved no phosphate application—was the poorest (3.9 t/ha), while the fertilizer alone and weed control alone plots gave intermediate yields (both 4.8 t/ha). The women were so impressed with the effect of adding phosphate fertilizer that they have clubbed together half of the cost for next season's fertilizer requirements. They are now seeking AGETA's help to find either a creditor or a donor to buy the remaining fertilizer. And all this after only one season of demonstration! The increase in production that the fertilizer should bring will enable the women to improve their families' lot in life. Once they make a profit, they want to diversify their agriculture into more valuable crops, such as banana, onion and lettuce. They also have a long-term vision of building a school for their children.



Zairabul Mint Ahmed, President of the Women's Cooperative Mushra Cidi, was very impressed with the WARDA/AGETA demonstrations

potential problems with the farmer, such as excessive weed growth in the field. Marco found some interesting results: "By comparing planned and actual activities, we learned that the farmers do not always know the best times for conducting the various farm activities (sowing, transplanting, applying herbicide and fertilizer, drainage, harvesting). Many also do not appreciate the relative importance of the major nutrients (nitrogen, phosphate and potassium) for crop growth."

To investigate the fertilizer problem more closely, trials are established simultaneously with farmers and on the research station. The aim of this participatory research is to determine what fertilizer to apply to the soil, and when it should be applied, for maximum benefit to the rice and to the farmer.

Marco elaborates further, "In the farmer participatory work, our first goal is to determine the benefits that they gain from their current fertilizer practices. To do this, we establish a small plot (10 × 10 m) within their field which is not given any fertilizer at all during the growing season—we call this the T0 plot. A major output from such



The unfertilized (T0) plot in a farmers' field

trials is the ability to determine how much of the fertilizer applied in the main field is actually recovered by the plants. For example, for nitrogen (N) fertilizer, the recovery rate is given by the following equation:

$$\text{N recovery} = \frac{(\text{N uptake in main field}) - (\text{N uptake in T0})}{(\text{N applied})}$$

In addition, the unfertilized plots give a clear indication of how much nutrient the plants can obtain directly from the soil.”

At the same time, trials are conducted both on station and with farmers in their fields on the effects of applying the different fertilizers. These are known as ‘nutrient-omission trials’ and constitute plots with no fertilization, plots with full fertilization, and others with one fertilizer component missing from each—for example, a plot fertilized with the full recommended doses of nitrogen and potassium, but with no phosphate. These trials are crucial as they show the importance of the different nutrients

(nitrogen, phosphate, potassium) to crop growth in the farmers’ fields.

“In order to put values to what we are seeing in the field, samples of soil, plants and irrigation water are taken to the laboratory for analysis. It is these lab analyses,” says Marco, “that enable us to determine the recovery rate of nitrogen fertilizer. They also enable us to detect other problems, such as salinity (salty soil or water), which may independently reduce yield however much the crop is fertilized. These analyses feed information into our on-station fertilizer trials in which we fine-tune the recommendations developed from the on-farm work.”

Giving back the results

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



Laboratory analysis is an important complement to field work



A group of farmers proudly pose before one of the posters from the end-of-season meeting

ers' field school, where the results are presented by means of posters. WARDA research assistant Baye Salif Diack, who acts as liaison with the various national partners, explains: "Most of these farmers were illiterate before they started to work with the extension agencies, but the extension agencies have run literacy classes in the local languages." The first poster always shows the variability among the farmers in the single scheme in the use of fertilizers, including amounts applied, timing, resulting yield and economic returns to applied fertilizer. "One clear result from the surveys was that farmers were not using the old fertilizer recommendations, and that rice yields were *not* related to the *amount* of fertilizer applied," comments Marco. A second poster often shows the effect of sowing date—again, this is real data collected from this group of farmers during this season: how does the choice of sowing date affect final yield, grain filling and timing of fertilization?

Another poster depicts fertilization in terms of sacks of fertilizer per hectare. It shows the farmers how much nutrient is supplied from the soil and how much they need to recover from applied fertilizer to reach a certain number of bags of paddy (per hectare). From the cost of the

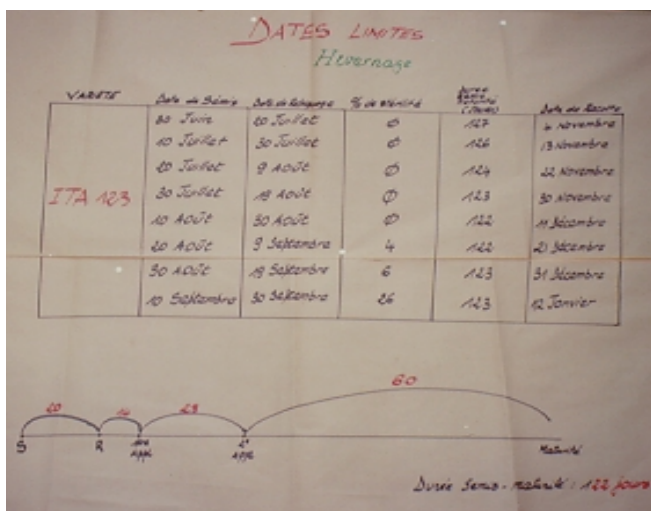
fertilizer and the market price of the grain, we can then give the farmers a clear indication of their returns to fertilizer use.

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

Where are we now?

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

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



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

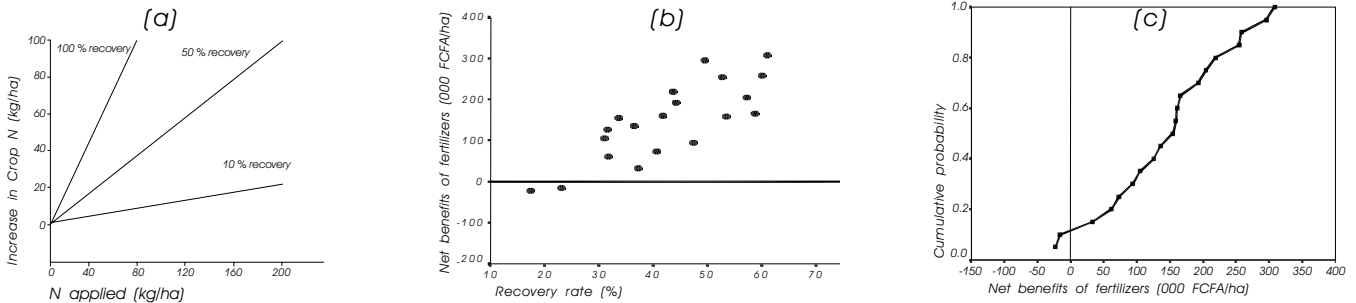


Figure 2. Apparent recovery of fertilizer nitrogen (a), net returns to fertilizer application related to nitrogen recovery rate (b), and probability of benefit to fertilizer application (c) at Guédé, Senegal

AGETA

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

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

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

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

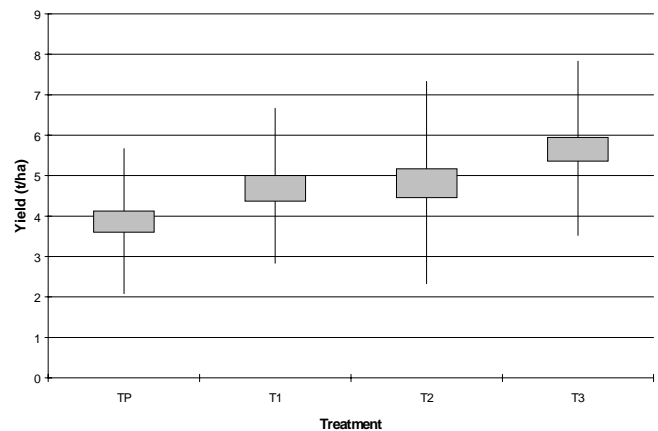


Figure 3. Application of recommended fertilizer and weed control (T3) gives an average of almost 2 t/ha more grain than the farmers' practice (TP); recommended fertilizer application (T1) and recommended weed control (T2) give intermediate values

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

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

SAED

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