MODEL PROJECT INFORMATION SHEET

FIELD PERFORMANCE OF SELECTED MUTANTS OF SORGHUM AND RICE

MALI - MLI/5/014

SUMMARY

Food self-sufficiency is a top priority in the national development plan of Mali. This model project would contribute to the sustainable development of the economically valuable local sorghum and African rice (*Oryza glaberrima*) cultivars by improving their yield and quality and thus eliminating the grain deficit. The use of integrated nuclear techniques in genetic upgrading and in determining the optimum fertilizer and water use is indispensable in realizing full production potential. Selected genotypes, derived from the advanced generation mutants of the native varieties of sorghum and African rice, will be tested in multi-location field trials and with different agronomic inputs. Mutants which show improved performance in yield and quality will be multiplied and released to growers for field tests. Based on the results of tests under varying agronomic inputs and growing conditions, a package of practices will be formulated for recommendation to farmers, who are the end users. The package will enable the farmers to realize the maximum possible yield potential of the released varieties, thus contributing to food self-sufficiency in Mali. Close co-operation between the two direct beneficiary institutes and the Ministry of Agriculture is considered in the design of the project. The project will improve the national capability in advanced mutation and plant breeding technologies and will integrate nuclear techniques in agronomic research. This will support sustainable agricultural development.

Project duration: 3 years. Total budget: US $451,500.

INTRODUCTION

Agriculture is the mainstay of the Malian economy, absorbing approximately 70% of the national labour force and contributing to slightly less than half of all GDP, with the tertiary sector accounting for more than a third. Mali is mainly an arid country, located in

sub-Saharan Africa, only 4% of the total surface area being devoted to rain-fed crops. An average US $90 million worth of cereals per year are imported, which accounts for 6.5% of GDP.

Food production has increased at a slower rate than the population over the past 20 years. In 1993, major crop production consisted of 691,000 tonnes of millet, 694, 384 tonnes of sorghum, 274,753 tonnes of maize, 388,483 tonnes of African rice and 21,945 tonnes of fonio. Achieving food self-sufficiency remains the top priority for the country. The strategy seeks to ensure that the population has access to food, that the income of farmers is increased and that the rural economy is stimulated. As climatic constraints heavily affect agricultural production and productivity, efforts are being directed towards "strategic" areas characterized by quick returns with short lead time, e.g. the use of selected varieties of pest control, where speedy results can be expected in terms of yield and removing the grain deficit. This has been recognized as a priority in the Fourth National Development Plan of Mali (1987-92) and is again a priority in the Fifth Plan at present under implementation.

The Agency has assisted (1985-88) two institutions in Mali, the Institut Polytechnique Rural (IPR) and the Institut d'Economie Rural (IER), for the improvement of sorghum and African rice (*Oryza glaberrima*) under a joint FAO/IAEA/Italy Co-ordinated Research Programme on improvement of basic food crops in Africa through plant breeding, including the use of induced mutations. Both crops are dependent upon rain and suffer from stress conditions which occur from time to time during the growth period. The project and subsequent national activities have resulted in several advanced generations of sorghum and African rice with improved characteristics including high yield (see next section).

There is a real need to further advance these promising findings, including the use of tissue culture techniques for advanced mutation breeding and the undertaking of multi-location field trials, to select high yielding plant varieties. Integrating this method with the use of nuclear techniques in soil studies is expected to maximize the yield. It is important to accelerate the attainment of concrete results with tangible benefits, which should lead eventually to the elimination of grain deficit, to improvement of the agriculture economy, and to food self-sufficiency. Close co-operation between the direct beneficiary institutes (IRP and IER) and the Ministry of Agriculture was considered in the design of the project to ensure that sufficient seeds of those food crops are multiplied and distributed to the end users (the farmers) and that the agronomic procedures are widely disseminated through effective methods of communication.

INTEGRATION OF NUCLEAR TECHNIQUES IN AGRONOMIC RESEARCH FOR SORGHUM AND AFRICAN RICE

A project on the improvement of sorghum, using radiation mutation techniques, was initiated in 1986 by the IPR de Katibougou, Koulikari (about 80 km from Bamako) with the aim of obtaining genetic variability by irradiating several local varieties of guinea type sorghum. This research has resulted in the production of several mutant lines in the M_8 generation with improved characteristics, notably drought resistance, maturity, yield and nutritive value. Although these mutants have not been tested in replicated field trials,

some of the material was handed to the farmers for cultivation. Their response showed that some mutants performed better than the local cultivars, which gives strong justification for multi-location fields trials. Some mutants have given an increased yield of 30-50% in farmers' fields while another is one month early in maturity and has higher protein content. There is also new material from experiments initiated in 1988 and 1989 which are now in M_4/M_5 generations. At present, three M_8 lines of sorghum are being tested in the field for their performance, and sufficient seed is being produced for multi-site trials with the selected mutants and the cultivars.

There is a need to establish a basic tissue culture facility to speed up breeding of sorghum. This facility would be useful to initiate in-vitro studies on the induction of variation and pre-selection of sorghum mutants for tolerance to heat and drought in the cultured cells, tissues and plants. It is well established that sorghum plants can be regenerated through shoot formation and somatic embryogenesis from callus culture of most cultivars. In-vitro irradiation of cell and callus cultures allows handling of extremely large populations in a small place and all year round, independently of weather. In-vitro grown plants, subjected to stress, can be selected and later tested in the field to confirm their improved tolerance to heat and drought. This technique will also introduce advanced plant breeding technologies in Mali and strengthen capability and technology transfer in this field.

The research work on improvement of African rice using radiation mutation techniques was initiated in 1988 by IER and yielded very useful mutants with white instead of red kernel. Seven such mutants have been advanced to M_5 generation and tested in small plot trials. All of them have white kernel, which carries a premium price in the market as it is the preferred colour by the consumer (the usual price of African rice is FCFA 100 per kg but is FCFA 250 for the mutants with white kernel). Two high yielding mutants (which have given an increased yield of 30%) mature very early. The mutants have been tested in multi-site trials in replicated plots grown along with the parent and another cultivar as controls.

It is well recognized, however, that high yielding plant varieties have high requirements for other inputs, especially nutrients, which must be met if the full yield potential is to be realized. It is therefore vital at this stage to obtain information on nutrient requirement of the promising mutants and to develop optimal fertilizer/water management strategies. The breeding efforts should now be integrated with studies on fertilizers/nutrient management so that a comprehensive package of agronomic practices (desired varieties, seeding rate, plant density, time of sowing, crop management during growth and development, methods for efficient cropping, nutrient and water management strategies etc.) can be formulated and handed to the Ministry of Agriculture and to the farmers who are the end users.

Nuclear techniques are integrated in various activities in this project. The mutants of African rice and sorghum which will be tested for field performance have been derived from gamma-ray irradiated seeds. In addition to the available advanced generation mutants, selected local cultivars of African rice and sorghum, which are well adapted but lack the desired traits, will be irradiated with gamma rays to obtain new variants. In soil studies, the isotopes ^{15}N and ^{32}P will be used to measure nutrient uptake/utilization by

plants, nitrogen fixation and nutrient turnover in soil. There are no other more appropriate techniques available.

OBJECTIVES

1. To contribute, using nuclear techniques, to the development of sustainable sorghum and African rice production through:

   (a) Induction and selection of improved mutants of local varieties of sorghum and African rice;

   (b) Field evaluation of the selected genotypes, their seed multiplication and release as new and improved varieties;

   (c) Development of a package of agronomic practices based on soil fertility and water management to realize the full potential of the released mutant varieties.

2. To enhance the national capability for advanced mutation and plant breeding technologies and for integrating nuclear techniques in agronomic research to support sustainable agricultural development.

The project will demonstrate the field performance of economically valuable mutants of sorghum and African rice and will develop agronomic practices for optimal fertilizer/nutrient and water use. The latter will include the appropriate use of local phosphate rock and exploitation of nitrogen-fixing legumes in the cropping system as affordable alternatives for fertilizing these crops.

PROJECT IMPLEMENTATION AND MONITORING

The Project Management Committee has already been established in November 1994 at Katibougou, and is composed of representatives from the direct recipient institutions (IPR and IER) and end users, the Extension Services of the Ministry of Agriculture, the IAEA, a representative of the farmers, and an independent scientist from ICRISAT. This Committee will, among other responsibilities, organize multi-site trials, evaluate results, and plan the outreach activity for the transfer of a package of agronomic practices and seed availability to the farmers. The Committee should also supervise the dissemination of the project's results and ensure that farmers are following the recommended agronomic practices. The project will be implemented in three phases.

Phase I (1995) will concentrate on implementation of field plot trials with selected mutants of sorghum and African rice at four to six present locations. Two staff members will be trained in plant tissue culture technique. Agronomists will be trained in the use of isotopes in soil/plant studies, and technicians in ^{15}N and ^{32}P analysis. Laboratory facilities for ^{15}N and ^{32}P analysis will be established. The performance of the mutants of sorghum and African rice within the recommended fertilizer package will be evaluated as a criterion for further selection. The seeds harvested from plot trials will be

analysed, and multiplied in sufficient quantity for multi-location field trials in the second and third years.

Phase II (1996) will focus on validation of the results obtained during Phase I and on the assessment of nutrient (nitrogen, phosphorus, potassium) requirement for the production of selected mutants of sorghum and African rice. Nutrient requirement studies will include the assessment of the effectiveness of locally available natural phosphate rock as a source of phosphorus for the selected mutants. Associated studies on plant density x-genotype interaction and nitrogen turnover in sustainable sorghum/African rice-legume cropping system will also be carried out and the establishment of a basic facility for tissue culture will be completed.

The final year of the project (Phase III) will be devoted to the preparation and distribution of protocols on recommended agronomic practices based on the results obtained from the studies on mutant performance and soil/plant/fertilizer relationship. Large scale seed multiplication and distribution of seed kits of the mutants of sorghum and African rice, selected during the first two phases, will be undertaken in collaboration with the Extension Services of the Ministry of Agriculture. The project will ensure that enough seeds are released to farmers together with recommendations on the related agronomic practices. A well planned national campaign for dissemination of relevant information, using mass media, will be effective in reaching the farmers.

It is planned that, during 1995, on-farm growing and farmers' response to one selected mutant each of sorghum and rice will be assessed. Distribution of seeds will be undertaken, and 20 seed kits of 250 g each will be supplied to 20 farmers from a selected village, who will plant it along with their own local variety and grow it in exactly the same way as they have done in the past. This will be repeated during 1996 with 40 farmers and in 1997 with 2000 farmers. This broad activity will be undertaken with the help of the local extension services.

The progress of the project will be monitored by the Project Management Committee. An annual progress report will be prepared by the direct beneficiaries and end users showing the degree of implementation, the achievements, problems encountered and actions needed for further progress. The report will be discussed at an annual meeting of the committee and other national and Agency representatives. Upon completion of the project, a seminar will be held at an appropriate venue for final evaluation of activities, including discussion of the main results, an assessment of the project's socioeconomic impact and its contribution to sustainable development. A model project final report will be prepared by the Agency on the basis of the seminar papers. Information material such as a short video film and a booklet will also be prepared and widely disseminated in the country.

NATIONAL COMMITMENT

The direct beneficiary institutions (IPR, IER) will make available sufficient seeds, adequate land for field trials, scientists (plant breeders, geneticists and soil scientists), premises to house the tissue culture, and ^{15}N and ^{32}P laboratory facilities. The Government, through the Ministry of Agriculture, will ensure that sufficient seeds of the promising

mutants of sorghum and African rice are multiplied, reasonably priced and distributed to farmers through the extension services. A convention (Memorandum of Understanding) to define the role, responsibility and duties of the direct beneficiary institutions (IPR, IER) and the Extension Services of the Ministry of Agriculture has been prepared for signature by the three institutions concerned.

THE AGENCY'S INPUT

For 1995-96, the Agency will provide equipment for a tissue culture laboratory, an emission spectrometer and accessories for ^{15}N analysis, a liquid scintillation counter and related equipment for ^{32}P studies. Expert services in soil and water management, mutation breeding and tissue culture as well as fellowship training will also be provided.

In 1997, further assistance is envisaged to help interpret the results obtained, validate the promising mutants of sorghum and African rice, and multiply sufficient seeds for release to farmers. The Agency will participate in the annual Project Co-ordination Committee meetings and will organize the evaluation seminar at the conclusion of the project. Follow-up expert services and additional fellowships are also foreseen.

IMPACT

The field performance of selected mutants of sorghum and African rice should demonstrate the potential yields which can be achieved from growing improved cultivars of these crops. Multiplication of the seeds of the selected varieties will provide farmers with sufficient seeds to introduce improved cultivars at the farm level. Optimal agronomic practices will be defined and handed over to local organizations for recommendation to farmers. Increased production of sorghum and African rice (the primary aim of the project) will help to increase farmers' incomes by a factor of 2 in the case of sorghum and 2.5 in the case of rice.

Based on the present prices of sorghum and African rice, and assuming that the new varieties will cover in a reasonable lead time 30% (Scenario A) and 50% (Scenario B) of the total surface areas at present cultivated with sorghum and rice, a rough estimate of the impact of the project on the national production of both crops gives the following figures:

Scenario A (conservative): 30% increase in the yield of sorghum and African rice due to the new varieties introduced:

Sorghum:	10% increase in production	Equivalent to US $18 million
African rice:	15% increase in production	Equivalent to US $24 million

Scenario B (realistic): 50% increase in the yield of sorghum and African rice due to the new varieties introduced:

Sorghum:	40% increase in production	Equivalent to US $88 million
African rice:	42% increase in production	Equivalent to US $40 million

In both cases it is assumed that the price of rice and sorghum and the exchange rate FCFA/US $ both remain constant over the next five years.

The project will strengthen the national capability in advanced mutation and plant breeding as well as in the integration of nuclear techniques in agronomic research. Sustainable human development will be supported.

FINANCES

The budget allocation for the project is US $451,500, distributed as follows:

Year	Experts		Equipment	Fellowships		Scientific Visits		Grp. Trg.	Sub-Contr.	Misc Comp.	Total
	M/D	US $	US $	M/D	US $	M/D	US $	US $	US $	US $	US $
1995	2/0	22,800	110,000	6/0	19,800	-	-	-	10,000	-	162,600
1996	2/0	24,000	100,000	6/0	20,700	-	-	-	10,000	-	154,700
1997	1/0	12,600	90,000	6/0	21,600	-	-	-	10,000	-	134,200
Total	5/0	59,400	300,000	18/0	62,100	-	-	-	30,000	-	451,500

Source of funding: TACF