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Sorghum and Rice: Mali

Agriculture is the mainstay of the Malian economy and yet cereal imports absorb 6.5% of GDP. Food self-sufficiency is therefore a national priority. The Joint FAO/IAEA Division is supporting a programme to improve local varieties of sorghum and rice by using nuclear techniques to develop new cultivars that will produce higher yields under Mali's semi-arid climatic conditions.

Food security

Mali is one of the largest of the sub-Saharan countries. Its staple crops are millet, sorghum, maize, rice and fonio but production of these cereals is failing to keep up with the needs of the growing population. Furthermore, rainfall is erratic and droughts are a recurring problem. But people need a reliable harvest of food, in poor as well as in good rainfall years. At the same time the nation needs to eliminate its grain deficit, improve farmers' incomes and stimulate the rural economy.

"Together with the help of dedicated scientists in Mali, we have developed varieties which exhibit very good characteristics"

Makdad Maksoudi IAEA

The mutant variety of sorghum (right) compared with the parent variety

Meeting the need

For some years the aim has been to improve the yield and quality of local food crops. IAEA has assisted two institutions in Mali, the Institut Polytechnique Rural and the Institut d'Economie Rural, to identify high-yielding varieties of sorghum and African rice (*Oryza glaberrima*) through plant breeding, including the use of nuclear techniques to induce mutations. Promising varieties have already been developed but work now needs to continue to ensure that farmers have the information they need to achieve full production potential. They need information on which varieties to choose, the seeding rate, plant density, time of sowing, crop management during growth and development, methods for efficient cropping, fertiliser use, and nutrient and water management.

Current state of play

The new generation of mutant varieties that have been introduced through the Model Project was developed by irradiating seeds with gamma rays. Some of the sorghum mutants have shown improvements over the traditional varieties or land races in one or more of the following characteristics:

- improved tolerance to drought
- high protein value
- shorter growing period
- higher yield

Farmers have been given some of these mutant varieties of sorghum for trial on an informal basis. Although fully replicated field trials have not yet taken place, initial results indicate that they out-perform local cultivars. Some mutants gave an increased yield of 30-50% in farmers' fields while another matured one month earlier and had a higher protein content than the parent.

Low dose radiation can introduce change at the genetic level, producing characteristics such as high yield or drought resistance.

Gamma irradiation of African rice has produced varieties with white instead of red kernels. Since these are much preferred by consumers, they fetch more than double the price in the market. Two high-yielding African rice mutants are currently being tested at a number of trial sites.

One of the advantages of mutation breeding, as opposed to conventional plant breeding, is that it conserves genetic diversity. This is because the mutants are produced by irradiating locally adapted material in order to change only one or two characteristics. Not only does this effectively conserve the land races but they will be conserved in situ because farmers will continue to grow them. There is no better way of conserving genetic diversity.

What needs to be done now - The Model Project

This Model Project is designed to build on the promising work already started. It has two overriding, principal objectives:

- to contribute, using nuclear techniques, to the development of sustainable sorghum and African rice production

White rice holds out promise for the future

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- to enhance the national capability for advanced mutation and plant breeding technologies and to integrate nuclear techniques into agronomic research.

Model Project components

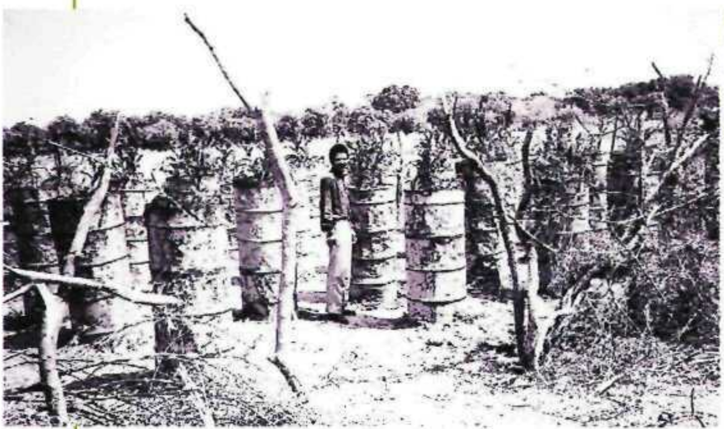
- Continuing field trials for testing *improved varieties already developed*, and any promising new mutants that are identified. Local cultivars of African rice and sorghum, which are well adapted but lack some desired characteristics, will be irradiated with gamma rays to obtain new variants.
- Basic tissue culture facilities to speed up the breeding of sorghum. *In vitro* irradiation of cell cultures means that extremely high numbers can be handled in a small place, all year round, regardless of the weather. *In vitro* grown plants can be selected after being subjected to stress. They can then be tested in the field to confirm their improved tolerance to heat and drought.
- Integrated plant breeding work and fertilizer management studies so that a comprehensive package of agronomic practices can be offered to the Ministry of Agriculture and to the farmers.
- An assessment of local phosphate rock as a potential source of fertilizer.
- An assessment of nitrogen fixing legumes in the cropping system for a low-cost, or no-cost alternative nitrogen fertilizer.
- Continuing seed multiplication and release of new and improved varieties as they complete field trials successfully.

Farmer's assessment

In the first year of the project, 20 farmers will be supplied with 20 seed kits of 250g each, of one selected mutant of sorghum and one of rice. Farmers will plant the seeds alongside their own varieties and grow them in exactly the same way as they have done in the past.

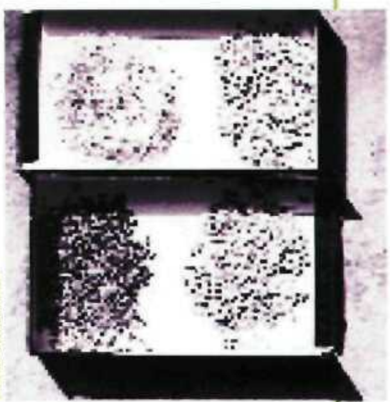
In the subsequent years, this will be extended to 40 and then 2,000 farmers.

Farmers will be asked to assess the new varieties, explain any problems encountered, and suggest what needs to be done.



Testing for drought resistance

THE field performance of selected mutants will demonstrate the potential yields which can be achieved from growing improved cultivars of these crops. Increased production should increase farmers' income if the mutants stand up to their anticipated performance. At a national level, even on a conservative estimate, there could be a 10% increase in production of sorghum and a 15% increase in production of African rice - a useful contribution to food security and a great help to rural families.



White kernel African rice (top) fetches a higher price in the market

How nuclear techniques help

Irradiation

Natural evolution results from spontaneous mutations and the 'survival of the fittest'. Irradiation induces mutations from which plant breeders can select those plants with characteristics that best fit their needs. Over the last thirty years, irradiation has become one of the plant breeders' most valuable tools. More than 1800 crop varieties worldwide have been developed in this way with billions of dollars added to farmers' incomes annually. A significant contribution has been the Standard Neutron Irradiation Facility (SNIF) which provides plant breeders with a pure source of fast neutrons in pool-type reactors. Other sources of irradiation are X-rays and gamma rays.

Isotopic labelling

High yielding varieties usually require high inputs of fertilizer if they are to achieve their maximum potential. Labelling with the isotopes ^{15}N and ^{32}P is used to measure nutrient uptake by selected varieties and the same technique can be used to measure nitrogen fixation and nutrient turnover in soil.

Isotopic labelling can also be used to study the relative merits of different fertilizer strategies - such as exactly when and where to place fertilizers. This helps to reduce fertilizer requirement to an absolute minimum and thereby saves production costs to the farmer and reduces damage to the environment.

Neutron moisture gauges

Water is the most limiting factor to crop production in arid and semi-arid countries such as Mali. It is therefore essential that the scarce water is optimally managed and efficiently used by plants. Neutron moisture gauges are ideal instruments for this purpose.

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