# Biofertilizer in Kenya:
# Research, production and extension dilemmas

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**Summary:-** For almost two decades, the University of Nairobi has been conducting research on biofertilizers in Kenya within the Microbial Resources Centre Network (MIRCEN) project. It has succeeded in developing a marketable biofertilizer known as BIOFIX. Notwithstanding its obvious potential to replace often unavailable and expensive chemical fertilizers, Kenya is still far from realizing wide-scale adoption of this innovation among its smallholder farmers.

## 1. Introduction

Biological nitrogen fixation (BNF) refers to the process of micro-organisms fixing atmospheric nitrogen, mostly within subsoil plant nodules, and making it available for assimilation by plants. Nitrogen supply is a key limiting factor in crop production. Rhizobium is the most studied and important genera of nitrogen fixing bacteria. It is able to fix atmospheric nitrogen in symbiosis with some types of leguminous plants. Biofertilizers have the potential of increasing yields of legumes as well as reducing the use and cost of chemical nitrogen fertilizers. The MIRCEN project at the University of Nairobi (see box) has since 1981 developed a Rhizobium inoculant known as BIOFIX, currently the main inoculant available on the local market. Although university researchers claim that BIOFIX is more cost-effective than inorganic nitrogen fertilizers, the use of this biofertilizer is very limited in Kenya.

## 2. Smallholder farmers' (bio)fertilizer needs.

Approximately 80 percent of Kenya's population of 27 million people live in rural areas. Most of them are smallholder farmers, relying on family labour to produce for self-subsistence or market. They account for more than 60 per cent of agricultural and food production in Kenya. Two-thirds of this population is located in Western, Central Nyanza and Eastern provinces. Smallholder farmers produce a range of crops including maize, sorghum, millet, beans, cow peas, pigeon peas, sweet potatoes, cassava, vegetables, sugar cane, coffee, tea, and raise cattle, sheep, goat and poultry. In 1994, an estimated 46 per cent of Kenya's rural population had a household revenue of less than US$ 360.

A major problem facing Kenya's smallholder farmers is declining soil fertility as a result of continuous cropping without replenishing soil nutrients. For instance, nitrogen is a limiting factor in crop production for 35 to 45 per cent of farmers in the highlands. In areas under intense cultivation, soils lack organic matter and important nutrients such as sulphur and phosphorus.

Current demand for land has led to increasing pressure on marginal land.
The need for low-cost and sustainable technical solutions to solve the soil fertility problem of smallholder farmers is apparent.

Smallholder farmers have few technological options which are compatible with both the physical and chemical status of their soils and their poor socio-economic conditions. Smallholder farmers' access to external inputs such as improved seed, fertilizers and pesticides has deteriorated especially since the Kenyan government removed subsidies on mineral fertilizers and other agricultural inputs.

In this context, BIOFIX seems an attractive technology. Results of field trials in Kabete and Embu in the late 1970s indicated that Biofix has good potentials. Selected Rhizobium strains fix more nitrogen as compared to applying a recommended 90 kg of mineral nitrogen fertilizer per ha common beans. Only 100 g of BIOFIX is required to inoculate the 10 kg of seed needed per hectare of common beans. Hence BIOFIX inoculant costs approximately US$ 1.25 per ha, which is only 10 per cent of the price of 90 kg of chemical nitrogen. Furthermore, BIOFIX is lighter to transport, requires less labour for application and is more environmentally friendly compared to chemical nitrogen.

In spite of all these attributes BIOFIX is used only by a few of Kenya's smallholder farmers. To explain this poor usage several related factors will be discussed, including physical limitations, quality considerations, low production levels, ineffective extension and lack of policy support at the national level.

**3. Kenya's biofertilizer research**

Rhizobium production in Kenya was initiated as part of a the Microbial Resources Centre Network (MIRCEN), supported by the United Nation's Education and Science Council (UNESCO). MIRCEN has centres across five continents, of which 3 are located in Africa: in Dakar (Senegal), Cairo (Egypt) and Nairobi (Kenya). The latter MIRCEN project was established by the Department of Soil Science and the Department of Botany of the University of Nairobi in 1977. The Nairobi MIRCEN project's mandate is to promote and transfer the BNF technology to researchers, government organizations and farmers in Kenya and the entire East African region. This includes collecting, preserving and testing of strains and preparing inoculants.

The Kenyan project has collected, isolated and preserved about 216 Rhizobium strains from both local and foreign sources. Out of these strains, it has developed inoculants for various legumes, including pulses, pasture legumes and trees. The Rhizobium inoculants in Kenya are developed by conventional methods. Although in other parts of the global research efforts on biofertilizers also include genetic engineering techniques to induce Rhizobia into the surface of the plant root cells of non-leguminous plants such as maize and rice, the benefits of such research efforts are far from being realized. As such, the conventional methods of collecting strains and testing their applicability has led to the most feasible results.

At present, the Nairobi MIRCEN project focuses on screening Rhizobium strains for tolerance to abiotic stress, such as high temperatures, soil acidity, drought and salinity. Two-thirds of Kenya's agricultural land suffers from these characteristics. The MIRCEN project reported to have isolated local strains of Rhizobium leguminosarium biovar phaseoli which tolerates temperatures as high as 42 degrees centigrade. Over 20 strains of Bradyrhizobium species isolated from groundnut nodules are tested for biological suitability and tolerance to acid soils and low levels of phosphorus. Worldwide, the use of Bradyrhizobium in soya bean has been the major success in biofertilizers. The Nairobi MIRCEN project is also exploring the potential of mycorrhiza, a soil fungus, for enhancing phosphorus and water uptake by plants. The project contends that the use of mycorrhiza inocula would be highly beneficial to soils of poor nutrient levels.

Other actors in Kenyan research on biofertilizers include:

- Kenya Forestry Research Institute (KEFRI) in collaboration with the International Centre for Agroforestry (ICRAF). They identified and characterized over 70 Rhizobium and mycorrhiza strains symbiotic to agroforestry tree species including Acacia albida, Acacia meamsii, Calliandra calothyrsus, Leucena leucocephala, Sesbania grandiflora and Sesbania sesban.
- The Department of Botany at Kenyatta University. Previously involved in the Nairobi MIRCEN project, this department is initiating its own research on mycorrhiza.
- The Department of Horticulture of the Jomo Kenyatta University of Agriculture and Technology (JKUAT). The department, which is establishing itself in the area of mycorrhiza research, has developed protocols for mycorrhiza for horticultural crops.

**4. BNF production and utilization**

Several biological and physical limitations restrict the use of biofertilizers by smallholder farmers in Kenya. The emphasis given to Rhizobium in biofertilizer research in Kenya, entails its restriction to leguminous crops only. The 700 kg of Rhizobium inoculant produced annually has targeted the following crops: common bean (47 per cent), lucerne (23 per cent), soya bean (14 per cent), desmodium, a leguminous pasture species (9 percent) and other minor legumes (7 per cent).

Additionally, farmers in the more marginal agricultural areas do not benefit from BIOFIX, partly due to physical restrictions. A wider use of Rhizobium inoculants in the marginal areas depends on developing strains which are tolerant to high temperatures, soil acidity, drought and salinity.

Another apparent problem affecting farmers' use of BIOFIX is its quality. Poor quality control in the production process as well as problems associated with its transportation and storage negatively affect the viability of the inoculant. Cold storage might improve its viability but is not a normal practice in Kenya. Aside from the infrastructure required for proper storage and transport, the quality control of Rhizobium inoculant also requires trained personnel and resources. This problem is a major concern to the University of Nairobi MIRCEN project, whose staff spends only a fraction of their time and resources on BNF production and quality control.

A further problem is that current levels of production of BIOFIX only meet 2 per cent of the potential demand for BNF by Kenyan farmers producing common beans. Assuming that all the Rhizobium inoculant produced in Kenya is sold and eventually utilized, an average of 700 kg BIOFIX produced annually by the project could fertilize an area of 7000 ha of common beans. However, this is too little, since an estimated 430,000 ha. of common beans are planted in Kenya each year.

**5. BNF distribution and extension**

Apart from factors linked to the characteristics and production level of BIOFIX, the way it is distributed also affects the poor usage. The vast majority of farmers in Kenya are not aware of the existence of BNF. In Kenya, BIOFIX is distributed to farmers in three ways.

Firstly, the Nairobi MIRCEN staff at the Pilot Production Plant at the Kabete Campus sell BIOFIX directly or by mail order. However, according to researchers at the University of Nairobi MIRCEN project, the project lacks both human and material resources to market

BIOFIX and improve its distribution. The project's emphasis is on research, and too little effort is put in the dissemination of its results.
Secondly, the extension staff of the Ministry of Agriculture, Livestock Development and Marketing (MLDM) sells BIOFIX through the District Agricultural offices either directly to farmers or through the various Agricultural shows in the country. Much has been written about the difficulties experienced in agricultural extension services in Kenya. By the lack of recordkeeping of sales and follow-up with farmers, for instance, the number of farmers who are using BIOFIX is not clearly known.Thirdly, the Kenya Institute of Organic Farming (KIOF) and the Organic Matter Management Network (OMMN), NGOs with integrated programmes on low-input sustainable agriculture, also distribute BIOFIX to farmers. KIOF and OMMN which account for the largest proportion of the Kenyan BIOFIX market, usually buy the inoculant directly from the Pilot Production Plant for the farmers' groups with which they work. Although the NGOs have good records of the farmers' groups with which they work, the actual number of individual farmers using BNF is not known. It seems that institutions developing and distributing BIOFIX, in particular the public universities and the extension service of the Ministry of Agriculture require a far more coherent coordination and documentation of their services, backed up by appropriate policy instruments.

**6. Policy issues of BNF in Kenya**

Kenya's 1994-96 Development Plan recognizes the fact that Kenya's agricultural production can hardly be increased by expanding the area under cultivation. A considerable potential, however, still exists in raising yields by increasing the use of manure, fertilizers, plant protection and weed control. Instead, Kenya has been facing a declining use of chemical fertilizers by smallholder farmers in recent years. This is mainly because of the adoption of structural adjustment policies by the Kenyan Government since the mid-1980s.

This included the privatization of the procurement and marketing of chemical fertilizer with the assistance of US Agency for International Development (USAID), and the abolition of subsidies on fertilizers in 1992. Although it was originally expected that fertilizer use by smallholders would increase because of increased competition and marketing efficiency, the majority of smallholder farmers are now unable to afford the high prices of fertilizers. According to the Kenya Agricultural Research Institute (KARI), "...a farmer currently has to sell about 10 kg of maize or 5 kg of beans to buy one kg of nitrogen or phosphate in the form of mineral fertilizers."

Where Kenya has a policy on chemical fertilizers, it lacks a clear national policy on biofertilizer research and extension. Biofertilizers are not mentioned in current national fertilizer use recommendations. Only Kenya's National Environmental Action Plan (NEAP) does mention biofertilizers as the environmentally friendly alternative to chemical fertilizers. It, however, fails to recognize the policy gaps in Kenya's agricultural research and development planning detrimental to poor usage of BNF by Kenyan farmers.

Policy related to BNF should address the need to strengthen institutions that serve the interests of smallholder farmers, enhance their capability, and improve their participation in adapting and testing BNF and extension services through the organization and exchange of information related to BNF. Increasing the involvement of other local actors, including private entrepreneurs, NGOs, farmers' cooperatives, local stockists, and trade associations may be more sustainable interventions for BNF distribution than total reliance on government agencies.

**7. Prospects of BNF in Kenya**

While biofertilizer could potentially benefit smallholder farming systems in Kenya, without adequate policy support to create a suitable environment for active participation of private sector institutions, its wider production and application are seriously limited.
The University of Nairobi MIRCEN project has recognized its limitations and is proposing to implement some changes in its BNF research and development. Firstly, it has proposed to strengthen training for both extension personnel and farmers in order to create awareness about BNF or biofertilizer.

Secondly, project plans are in progress to privatize the BIOFIX production unit in order to increase production to meet potential demand for BIOFIX in the country. Present university facilities will remain for training researchers and extension workers in the region. Furthermore, the MIRCEN project would prefer to identify entrepreneurs who can take over the distribution, marketing, and sales of BIOFIX so that MIRCEN personnel can concentrate on the research and quality control aspect of BNF.

Thirdly, the MIRCEN project is actively seeking collaboration with other institutions. The project is trying to develop agreements with groups such as FAO's small scale inputs project and the soya beans project of the German Society for Technical Cooperation (GTZ) which support smallholder legume seed production in Kenya. In addition, the Kenya Agricultural Biotechnology Platform which is supported by the Directorate General for International Cooperation (DGIS) of the Netherlands' Ministry of Foreign Affairs is considering support to a project for inoculant production and transfer through the MIRCEN project.

From the onset, the BNF project in Kenya did not involve farmers in the development of this technology. It can be expected that farmers' participation could have a direct influence on: (1) the setting of research priorities, especially in addressing marginal areas of the country where use of BNF is limited by physical constraints and farmers lack access to chemical fertilizers; (2) feedback to scientists on the suitability of Rhizobium strains following farmer-controlled on-farm trials; (3) awareness creation; and (4) farmer to farmer extension and adoption of BNF. A response to this challenge requires a shift in research and extension towards user participation which would include scientists, extension workers and private sector institutions working together with farmers to involve the latter in the entire BNF innovation process.
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