Capturing atmospheric nitrogen for enhancing soil fertility and crop production in Benin

THE CHALLENGE

Benin is predominantly an agricultural country with the agricultural sector accounting for 35% of GDP in 2014[1]. About 60% of the economically active population is engaged in agriculture. However, poor soil fertility as a result of low nitrogen (N), phosphorus (P) and potassium (K) deficiencies induced land degradation which is widespread across Benin, leading to low agricultural productivity. Access to fertilizer is a major constraint due to cost.

Maize is the most important crop in the agricultural economy of the Benin Republic. It occupies nearly 54% of the 1,100,000 hectares of food crop production[2]. More than 50% of the national maize harvests are produced in the southern region where rainfall patterns allow two harvests per year. However, yield remained low and despite many efforts to overcome these constraints and reduce poverty in Benin, food security remains fragile. Addressing soil fertility and increasing crop productivity is of paramount importance for the government.

THE PROJECT

Through the Joint FAO/IAEA Division of Nuclear Techniques in Food and Agriculture and the Technical Cooperation (TC) Department of IAEA and in collaboration with the Faculty of Agronomic Sciences of the University of Abomey-Calavi (FSA/UAC) and the National Institute of Agricultural Researches in Benin (INRAB) in Benin, two TC projects[3] were implemented to improve yield and soil fertility by using dual-purpose grain legumes, such as soybean and groundnut, integrated with crops and livestock systems. Herbaceous and tree crops with rhizobia inoculants and fertilizer were used to increase the performance of legumes to acquire atmospheric nitrogen through biological nitrogen fixation (BNF) and improve soil fertility and yield.

Fig. 1. Soil is degraded due to poor soil fertility in some areas of Benin

Inoculation and phosphorus application fixed the highest N, with soybean yield increased from an average of 770 to 2,396 kg/ha (210%), while groundnut pod yield increased from an average of 300 to 1,220 kg/ha (300%)[4]. Similarly maize yield increased from 1,325 to 2,097 kg/ha (50% increase) in rotation with legumes. For the farmers the above increase in soybean, groundnut and maize yield meant an increase of income from USD 193 to 866 per hectare from the cropping systems[5].

THE TECHNOLOGY

Nitrogen is the most important nutrient for plant growth. Adding isotopically labelled (with N-15) fertilizer to the soil-plant system and tracking its movement in the soil and plant helps to quantify the amount of N derived by a legume crop through biological nitrogen fixation. This isotopic technique also helps to quantify how efficiently fertilizer N is used by crops so that management practices can be developed to increase crop N-use efficiency.

THE IMPACT

The inoculation of legumes contributed to improved soil fertility and subsequent cereal crops yields. Soybean grown in farmers' fields fixed an average of 50 to 150 kg N/ha. Small holder farmers are now able to overcome the constraints related to the high cost of mineral fertilizers. A significant marginal rate of returns has been obtained as a result of the yield increase.

Through the Federation of Farmers Unions of Benin FUPRO-Benin and NGOs, the project intensified farmers' interest in integrated soil fertility management practices. More than 5,000 farmers were trained by the Faculty of Agronomic Sciences to encourage the use of these technologies to enhance BNF, improve soil fertility and increase crops yields.

Fig. 2. Soybean with and without rhizobia inoculation

The demand for inoculating soybean to enhance soil fertility has increased tremendously in Benin, with areas growing the crops increasing from 2,200 to 300,000 ha between 1999 and 2014. By enhancing soybean rhizobia inoculation over the 300,000 ha area, an estimated USD 10 million can be saved from importing mineral fertilizer[6].

Fig. 3. The effect of Bradyrhizobial inoculation and phosphorus on soybean growth and biomass production

[1] http://gain.fas.usda.gov/RecentGAINPublications/AgriculturalSituation_Lagos_Benin_3-20-2014.pdf.
[2] FAO, 2009. http://www.fao.org/ag/agp/agpc/doc/counprof/benin/Benin.htm.
[3] BEN5005 on Improving Maize and Yam-Based Cropping Systems and Soil Fertility.
BEN5007 on Soil, Crop and Livestock Integration for Sustainable Agriculture Development through the Establishment of a National Laboratory Network.
[4] Based on internal data.
[5] Based on internal data.
[6] Based on internal data.

For further information, please visit:

The Joint FAO/IAEA Division of Nuclear Techniques in Food and Agriculture
International Atomic Energy Agency, Wagramer Strasse 5, PO Box 100,
1400 Vienna, Austria
www-naweb.iaea.org/nafa/swmn