Nitrogen fixation on a national scale

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Intensive grazing of vast areas combined with continuous cultivation of wheat, barley, maize, sorghum and sunflower under conventional tillage practices, without proper fertilisation or erosion control, have been degrading land in Uruguay ever since the first European emigrants arrived in the country in 1910. Farmers and producers abandoned the land once it became infertile and degraded and moved on to areas where soils were still productive. As a result the problem of soil depletion grew. In 1959 the government, technicians, NGOs and farmers unions started to discuss the problem. A plan for the development of agriculture - the *Plan de Desarrollo Agropecuario* – was developed. This "Agricultural Development Plan" was set up to improve productivity in the short and long terms and included all agricultural land. Special emphasis was given to the development of pasture-crop rotations.

Bacteria to the rescue

In 1960, using positive experiences with legume inoculation in Australia and New Zealand, researchers of the former Laboratory of Soil Microbiology and Inoculants (now the Department of Soil Microbiology of the Department of Agriculture) started to work on biological nitrogen fixation (BNF) involving the soil bacteria Rhizobium. These organisms live in association with specific plants, forming small nodules (swellings) on the roots. They fix nitrogen from the air into the soil and in doing so provide crops with one of the elements essential for good growth and yields.

The research group worked in close collaboration with rhizobiologists, plant breeders, agronomists, farmers and extensionists to identify, select and test native Rhizobium strains that were well adapted to specific soils and host plants. In addition, native and introduced pasture varieties that responded well to the presence of Rhizobium were selected. In collaboration with farmers, field and on-station trials were established across the whole of Uruguay to study the efficiency of established pasture-crop rotation practices, such as the use of a mix of legume and non-legume pastures in rotation with winter crops like wheat and barley, and summer crops such as sunflowers, maize and sorghum.

Improved pasture-crop rotations were established. Farmers were given technical support and benefited from a credit plan that covered 80% of any investments they made. Adoption of the BNF technology was further facilitated by the fact that it is easily applied in the field. Rhizobium bacteria, mixed with sterile soil, are fixed to the seeds by using a special type of glue, after which sowing takes place.

The livestock sector has greatly benefited from BNF technology. Photo: Federación Uruguaya de Grupos CREA (FUCREA)

A gene-bank of N-fixing and other microorganisms was established at the Ministry of Agriculture's Department of Microbiology to serve as a source of high-quality germplasm for researchers, extensionists and commercial producers. The private sector was closely involved in the development of the BNF technology investing in both the production and multiplication of the required Rhizobium strains. Today, three enterprises produce high-quality Rhizobium for Uruguay and other South American countries.

Good for the farmers, good for the country

BNF in Uruguay continues to be developed and improved and, over the last 40 years, the technology has brought considerable economic, ecological and social benefits to those who have used it. The country has saved millions of dollars through reducing imports of nitrogen fertiliser. Individual farmers have greatly benefited because Rhizobium is cheaper to buy than urea-based fertilizers. Currently one application of Rhizobium costs one US$/ha whereas one application of urea fertiliser costs US$50 per hectare. BNF technology has the capacity to fix and incorporate 250 kg per hectare of nitrogen in the soil in a very efficient way. Farmers are well aware of the benefits and as a result rotation with legumes and inoculation with Rhizobium is now being used by nearly all arable farmers.

BNF's contribution in Uruguay

- Soybean yields have increased 800-1000 kg/ha/year (a 40% increase) on land where they have not previous been cultivated and where Rhizobium is used.
- Pea producers using BNF have recorded yield increases of up to 240%.
- Each year savings in the order of 90 million dollars have been made because of farmers using Rhizobium rather than buying in fertiliser for forage legume production.

Explaining the success of BNF

This initiative is a good example of the planning and implementation of a national, government supported strategy with an ecological and multi-disciplinary approach. There was a strong functional relationship between the government, industry and farmers. The spontaneous integration of these stakeholders made it easy to define limiting factors, find solutions and apply these in short term. An aspect worth mentioning is that BNF was not an objective in itself but a valuable tool that could be used to meet the goal of improved productivity in the short and long term. While farmer pressure and government support was essential in the process, the key for success was the excellent performance of BNF technology in the field, leading to its successful adoption and the improved production systems currently in place. ■

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Following website provides more information on Rhizobium and its use: http://fp.chasque.apc.org:8081/microlab/LMSCI/LMSCI.htm