Phaseolus vulgaris or the common bean is the world's most grown leguminous plant. In Latin America in particular – its original biotope – it is the traditional crop grown by small-scale farmers and provides a very popular food renowned for its nutritional qualities. It is, however, exposed to a number of threats, one of which is abiotic stress. The European and Latin American partners working on the OpUsLi project have undertaken important work in both the field and the laboratory to identify the complex causes of this phenomenon and to select the most resistant seeds.

COMBATING 'bean stress'

50% of the world's beans are grown in Central and South America. The remainder are grown either in Europe or South East Asia. This leguminous plant is very rich in protein and iron as well as being a valuable source of dietary fibre and complex carbohydrates. Its contribution to a balanced diet is particularly important in poor countries.

Abiotic stress is caused directly by the environment, unlike biotic stress that is caused by living organisms such as microbes or insects. When plants are faced with imbalances in temperature, sunlight, water supply or nutrient content of the soil, for example, the resulting stress leads to impaired photosynthesis, harming their development and yield and perhaps resulting in the crop withering away entirely.

Photosynthesis is, in fact, something of a paradox for plant growth. While plants need it for their carbon metabolism and development and seek to maximise their ability to absorb and use sunlight, the effect of the light energy that exceeds their photosynthesising capacity is to trigger the production of oxygen radicals that are harmful to plant growth – known as photoinhibition.

Water, soil and air

In the case of the common bean, the photosynthetic balance is also very much influenced by the accumulated effects of other environmental factors. The bean plant is very sensitive to drought – especially when grown on sloping terrain where there is insufficient irrigation – as well as to nutrient deficiencies in the soil. Notable examples of the latter are the phosphate deficiencies in many volcanic soils on the Pacific Coast and nitrogen deficiency associated with high temperatures and excessive sunlight. Another factor linked to abiotic stress is ultraviolet rays. In this respect, the ozone hole in the Antarctic region has exacerbated the problem, not only in the southern zone of the South American continent (Chile and Argentina) but also in countries such as Colombia, Ecuador, Peru and Bolivia.

The plants are not totally powerless, however, and the hereditary constituents (genotypes) of certain varieties develop responses that enable them to resist these environmental imbalances. However, we know very little about these survival mechanisms at the molecular level.

The work undertaken by researchers not only concerned agronomical improvements but also the promotion of bean growing and consumption, especially in the tropical regions of Cochabamba in Bolivia where the diet is often very poor in proteins.

Field and laboratory

The first task for the OpUsLi[1] researchers from Latin America (Bolivia, Chile, Colombia) and Europe (Italy, United Kingdom, Germany) was to select seed samples from Chile University's Faculty of Agriculture, the gene bank at the International Centre for Tropical Agriculture (CIAT) in Colombia, and from Bolivian collections. This genetic material was then used to carry out experiments on how these varieties behave in the field, at five very different sites.

At the same time, extensive tests were carried out in the partners' European laboratories, in the fields of biochemistry, molecular biology, physiology, genetics and agriculture. "The agronomic characterisations of over 70 genotypes were completed. Variations in the data obtained by trials carried out during three seasons, backed up by extensive laboratory research, made it possible to identify the cell and hormonal mechanisms that influence the hydration state of the leaves and their drought tolerance," explains Peter Horton of Sheffield University's Department of Molecular Biology and Biotechnology (UK), the project coordinator. "The complex interactions between the various stress factors – namely UV, temperature, relationship between ultraviolet rays and phosphorous content, etc. – were identified and suggest that we need to redefine very carefully the notion of tolerance to multiple stress."

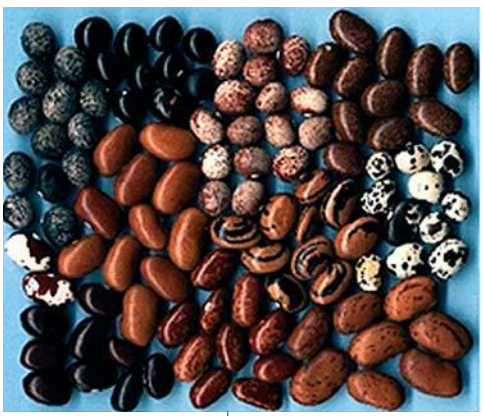
The productivity objective

Statistical analyses made it possible to determine productivity in cases ranging from the worst to the best harvesting conditions. Agronomical practices were also evaluated, such as planting density, chemical treatments, and vaccination with rhizobium and irrigation.

"A new approach to the prevention of abscission – a process by which parts of the plant, whether the fruit, vegetable or leaf, become detached – was developed by the Chile University team by using a mixture that releases nitric oxide, a recently identified growth regulator. When applied to beans it can boost the harvest significantly," explains Rodrigo Meneses of the Faculty of Agricultural Sciences at the Mayor de San Simon University (Bolivia), a researcher and OpUsLi partner who had already worked with Dutch teams on the biological fixing of nitrogen in plants. "But on this occasion the experimentation was widened to include a number of countries, enabling us to probe deeper than previous research," he explains.

The work undertaken in Bolivia not only concerned agronomical improvements, but also the promotion of bean growing and consumption, especially in the tropical regions of Cochabamba where the diet is often very poor in protein. "We helped farmers evaluate what varieties of bean are appropriate – even providing them with cooking recipes."

The land in these regions is often dominated by the cocoa crop, which is more attractive economically to these poor populations. "However, we did manage to introduce bean production in certain areas – not for sale but for own consumption," explains Manuel Pinto, a professor at the University of Chile's Department of Plant Production. "Our Bolivian partners, who were responsible for the educational aspects of the project, succeeded in making parents aware of the nutritional value of this crop for their children." ■



Four varieties studied by Eu-Bean researchers: Pinto 114, Tortola, Arroz Tuscola and Orfeo.

(1) Characterisation of South American genotypes of bean for optimal use of light under abiotic stress.

To find out more

- www.eubean.net/

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Agrecila & Erbic

Two other international research projects supported by the EU have also concentrated on growing the bean as a basic food crop.

Complementing the OpUsLi objectives, Agrecila[1] aims to combat osmotic stress – caused by salinity and drought – by means of metabolic engineering of the plant and its host bacteria rhizobium that is specific to the bean. German, Mexican and Peruvian researchers are working on the project which is being coordinated by the University of Seville.

The second project, ERBIC[2], was carried out in 2001 and 2002. One of its principal aims was to find a way of reducing crop losses due to *Colletotrichum lindemutianum* which causes anthracnose, a fungal disease that attacks this leguminous plant. The project team comprised partners from France, Ireland, Tanzania, Mexico and Costa Rica.

(1) Agriculture under extreme environmental conditions in Latin America by using osmoprotection genes to generate stress-resistant bean plants.
(2) Study of the pathosystem of common bean anthracnose and identification of durable resistance sources to reduce yield losses in Latin American and Africa.

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