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Developing **biofertilisers** for Chinese farmers

Small farmers in China cannot afford expensive chemical fertilisers, but suffer low yields because their soils are often phosphate-deficient. A European-Chinese project has been working to provide the farmers with an alternative solution, using soil fungi that associate with plant roots to improve phosphate acquisition. The three-year project has entirely developed these `biofertilisers' for three staple crops, from initial identification and culture of fungi from Chinese soils to provision of inoculum to small farmers. Yield increases of up to 11 % were recorded in field trials.

Title
Mycorrhiza technology for staple food crop production in small-scale sustainable agriculture in China (MYCHINTEC)

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About 74% of agricultural soil in China is phosphate-deficient. Phosphate is an essential nutrient for plant growth, so this deficiency reduces crop yields. Many farmers struggling with these poor soils cannot afford chemical fertilisers, which cost up to €225 per hectare. A European and Chinese collaborative project set up in 2000 has given farmers an alternative way to improve the soil, using the natural soil-enhancing abilities of Arbuscular Mycorrhizal Fungi (AMF). This relatively new biotechnology is cheap enough to be accessible but, unlike phosphate fertilisers, does not pollute the environment. The there-year project, Mychintec, involves six partner organisations - three in China and three in Europe.

Root partners

AMF are naturally occurring, microscopic fungi that form a partnership with plant roots in the soil. The fungus takes sugars from the plant, and the plant gains nutrients, usually phosphate, from the fungus. "Mycorrhizal fungi are able to explore the soil more efficiently than roots," explains project coordinator Vivienne Gianinazzi-Pearson, who is based at the Institut National de la Recherche Agronomique (INRA) in France. "The fungi accumulate phosphate and release it to the plant." More than 80% of plant families form relationships with mycorrhizal fungi, including most crop plants.

Although these fungi are naturally present in soils, the community in a given soil is not always as effective as it could be. AMF differ in their ability to provide phosphate to plants and there is great scope for enhancing soil fertility by optimising the fungal partners in phosphate-poor soils. A second benefit of AMF, not yet clearly understood, is protection against soil pathogens such as nematodes.

Working together

Mychintec brought together two pre-existing consortia of Chinese and European scientists working on the potential of biofertilisers. INRA first worked with the UK's Institute of Biotechnology to develop an international database of mycorrhizal fungi in 1993, and has collaborated with scientists at the Huazhong Agricultural University in central China since then. At a meeting in 1998, this team dis-

Mass production of fungal inoculum at the small Chinese company, Kaifa.

Sweet potato crop in Tangshan, north China.

covered another group of scientists, from Hohenheim University in Germany and the China Agricultural University in northern China. Along with scientists from Hong Kong, in the south, a new cross-China collaboration was born.

"We decided to focus on mycorrhizal fungi, and gather together the whole chain of development, from identifying fungi to a pre-commercial inoculum product," says Gianinazzi-Pearson. The project involves two small biotechnology companies - a French company, Biorize, which produces AMF inoculum for the European horticulture industry and a Chinese company, Kaifa, which develops biotechnologies for Chinese farmers.

Fungal biofertilisers are not well suited to European agriculture, whose large-scale automated planting methods are not amenable to inoculating soil around plant roots. By contrast, the three staple crops involved in Mychintec - sweet potato, maize and cassava - are usually planted out by hand in China. "Hand-planting makes it easy to introduce small amounts of inoculum," says Gianinazzi-Pearson. Sweet potato is widely grown for food in northern China, maize is popular in central China, and cassava is a staple in southern China.

e-Fungi

The first stage of the project was to take soil and root samples from the three different Chinese regions. Fungi were isolated and cultured from these samples. Thirty-one fungal isolates were added to the international database of AMF and information about them made available to researchers on the internet in English, Spanish, French and Chinese (see contact information). The isolates themselves are maintained at the Chinese institutions which collected the samples. Scientists at INRA analysed their genetic sequences and devised fungus-specific DNA probes that could track the fate of individual fungal types in soil and plant roots.

The second phase of the project, led by the Chinese Agricultural University in Beijing, was to test the fungi for their ability to provide extra phosphate to plants. Some were better than others, and scientists discovered that the activity of certain genes could be used as indicators of efficiency. "Of the 31 isolates added to the database, around 15 have really interesting plant fertiliser abilities," says Gianinazzi-Pearson.

Satisfied customers

Finally, with advice from Biorize, the Chinese company Kaifa cultured the mycorrhizal fungi into a soil-based inoculum useable by farmers, which was taken to Chinese farms for trials in 2002 and 2003. Results were extremely encouraging. Crop yields increased by up to 11 % in sweet potato and maize, and there was a quality increase of up to 26%.

The farmers involved in the trials are pleased with the system. "At first, they were unsure," says Gianinazzi-Pearson. "Chinese small farmers are very ecologically minded, and used to working with their soils. They are distrustful of anything that is unnatural." In a recent meeting, she asked farmers what they thought. "Now they are very enthusiastic and would have no hesitation in buying the technology," she reports. Kaifa is keen to commercialise the biofertilisers, which could be on the market in two or three years.