They capture nitrogen from the air and soil phosphorus

Soil microorganisms are at the heart of the new green revolution

Chantal Hamel is clear: "We must innovate. The nitrogen in synthetic fertilizers is derived from expensive processes. Reserves of phosphorus are measured in decades; the mines will be empty someday. In addition, the cultivation of biofuels is now competing with food crops and mobilizing soils and inputs. And there will be 8 billion people on Earth in fifteen years! "

The alternative is to develop farming practices based on the properties and activities of soil microorganisms to allow crops to feed effectively; this is what fascinates Chantal Hamel, a soil microbiologist who works at Swift Current, Saskatchewan, for Agriculture and Agri-Food Canada (AAFC).

The concept behind her work is simple; it is based on the association of soil fungi and bacteria with plants to ensure their mutual survival. The plant captures carbon from the air to produce energy (in the form of sugars) through photosynthesis. Fungi and bacteria, which cannot photosynthesize, need this energy, so they settle in the roots of plants to absorb the sugars provided by the plant and give in exchange minerals they draw out of the air and soil. The plant and its associated microorganisms exchange what they need and this process is free, natural, and requires no human intervention. "The nitrogen supplied by microorganisms does not cost anything, while it is very expensive to industrially capture nitrogen from the air in the form available to plants. Fixing nitrogen from the air is done by applying extreme pressure at very high temperatures, using the Haber-Bosch process, and the energy required for this operation represents 70% of the cost of the generated nitrogen fertilizer. But even though they provide important services for free, few people are interested in the life of soil microorganisms, deplores Chantal Hamel. Indeed, soil microbiologists are few and AAFC research budgets decline from year to year; researchers who retire are not replaced. And yet there is so much work to do, confirms Chantal Hamel.

Chantal Hamel became interested in mushrooms while walking in the countryside of Rivière à Pierre, north of Quebec City where, as a child, she spent the summer at the cottage of her grandparents. Subsequently, more attracted by the beauty of the world than by mathematics, she headed towards the 'big city' of Montreal. After several years on the job market, she resumed her studies, this time in agronomy at McGill, being interested in nature and the food needs of the planet. Her first session was a challenge: she had to learn the language of Shakespeare along with the basics of agronomy. Then she enthusiastically began a Master's degree on mycorrhizal fungi with a grant from the Research Council Natural Sciences and Engineering Research Council of Canada (NSERC). This was the beginning of a long scientific quest to discover more about the role of fungi in the soil, those tiny microbes that are difficult to count and often associated with disease rather than soil health. Her subsequent doctoral thesis dealt with the transfer of nitrogen from nitrogen-fixing legumes and associated grasses with mycorrhizal fungi.

Plants do not have the ability to move to survive, like animals. Instead, their strategy is to change their environment, attracting beneficial organisms such as rhizobia and mycorrhizal fungi with which they partner. This symbiosis is very effective; the plant is an almost infinite source of energy because it feeds from the sun's rays while nourishing the fungi and rhizobia housed in its roots. But this symbiosis does not develop much when nitrogen or phosphorus fertilizers are applied: with this plentiful supply of nutrients, the plant does not need to depend on this symbiosis and so represses it. The plant loses the benefits of this association, and the now free beneficial soil fungi do not grow and may even disappear.

Organic farming relies heavily on the development of a rich soil to ensure fertility. The living soil is home to billions of microorganisms that live in symbiosis with plants. Chantal Hamel has a research project with the Organic Science Cluster, which is to define "Predictive tools for characterizing mycorrhizal contributions to phosphorus uptake by organic crops". She explains the project,

The fungus-plant symbiosis is essential for organic production, which feed on plants naturally without ecological imbalances caused by the application of synthetic fertilizers.

"You start at the base and identify fungi in the soils of wheat fields on different sites (SK, NS, MB, AB, ON). The goal is to understand what is growing in organic soils. We need the cooperation of producers to gather information about the farming methods that are used, and as organic farmers and seed producers keep records, we used the directory of organic and seed producers to choose our sample sites, distributing the types of sampling on various types of soil whose description is already documented in the federal federal databases. We then study the fungi content of these soil types and models are made to predict the likely contribution of fungi in a given site based on indicators. "

Knowing what's in a field is expensive, because the biotrophic fungi do not grow in laboratory dishes, only on live plants. They are microscopic and hard to identify. Samples will be screened, centrifuged, separated according to the weight of the constituents and examined microscopically. Analysis of nucleic DNA to identify fungal species is not possible, due to the numerous copies of unique genes inside fungi. Instead, researchers examine mitochondrial DNA, which is unique in mitochondria.

Some bacteria associated with nitrogen fixation are also very interesting because they stimulate plant growth; research will confirm the potential of these legumes inoculants and will help in selecting the most rewarding legumes for the soil and crops.

The fungus-plant symbiosis is essential for organic production, where plants feed naturally in the absence of the ecological imbalances caused by the application of synthetic fertilizers.
"It remains to convince industry to invest in this type of research. The research programs of AAFC require an industry contribution of 25% to the funding of projects for their acceptance. There is a lot of outreach to do to promote innovative projects whose scope is the medium to long term. Society, governments and non-organic producers are rather courted by the powerful agro-chemical industry," says Chantal Hamel, observing the current prevalence of short-term views in many programs.

She also observes that many people in Saskatchewan do not make the connection between the meals they eat and agriculture. Food in grocery stores is almost all imported from California, China or New Zealand, a tendency which cannot be described as sustainable consumption. Canola has become the second most prevalent cultivated crop in Saskatchewan, wheat remaining the first, and the rise of the demand for canola oil has resulted in low crop diversification. GM canola does not "mycorrhize"; the production becomes increasingly dependent on synthetic fertilizers and the soil's ability to provide phosphorus is reduced. However, phosphorus supply is the major challenge of production, because it is poorly soluble and slowly available. The soil fungi solubilize phosphorus and make it available to allow targeted, clean and efficient use of this precious resource, which is why they are necessary to maintain the biodiversity of soils.

In the summer, Chantal admires the flowers in her native plant garden that requires no care. She observes the minks, ducks and pelicans during her morning jog along the river when getting to work, and finds that life in Swift Current is very nice.

The morning of her interview, she discovered an effective biochemical marker for quantifying mycorrhizal fungi, a marker so perfect that she felt much emotion. "Sometimes we find!" she says happily.