Of cabbages and things

Cabbage

Healthy swedes (rutabagas)

Plasmodiophora brassicae are nasty little beasts of uncertain origins. They may relate to the protozoa, single celled organisms which are neither plants nor animals, and are only a few thousandths of a millimeter wide and long. Most of their relatives in this microscopic world are harmless, but some distant cousins are *Plasmodium* species, which cause malaria in humans and *Amoeba* species which cause dysentery. *Plasmodiophora brassicae's* parasitic way of life is to attack vegetables of the brassica family, causing the debilitating clubroot disease. Now, evidence is emerging that boron might play an important part in keeping its effects in check.

Crops of the brassica family are of enormous worldwide importance. Arguably they are second only to cereals in their contribution to human diet and welfare. They range from the cabbages, cauliflowers, calabrese and brussels sprouts familiar in the western world, to a wide array of leafy and root vegetables widespread in India, China and Japan. The Chinese cabbage, for example, is one of the most important foodstuffs of the Orient. Much of the world supply of vegetable oil comes from rape and mustard seed, while swedes (rutabagas) and turnips are important animal fodder crops in Europe and North America.

Healthy roots on left; clubroot on right

There wouldn't be much of a problem hosting a parasite like *Plasmodiophora* if it didn't have such rampant and dire side effects. In clubroot disease, the plant roots are distorted by massive galls, which inhibit water and nutrient uptake. The grossly deformed roots sap carbohydrates from the leaves and deprive developing flowers. The foliage turns bluish-green, then yellow and then wilts: the plant is past the point of no return and nothing can restore it to health.

Does boron actually fight the invasion or effects of invaders within the plant itself?

Not surprisingly, this is responsible for drastic crop losses and poor quality. It is also virtually impossible, certainly in intensively-farmed regimes, to eradicate the parasite from the soil in which it spends much of its lifecycle.

When *Plasmodiophora* spores germinate in the soil, the tiny organisms swim around and as soon as they meet a root hair they attach and inject their own cell contents into the root. The genetic material multiplies inside the plant, and it is believed that this presence upsets the host hormone metabolism and leads to uncontrolled cell growth - almost a plant cancer. Once established and now mature, the parasites release billions of new spores back into the soil. It is a very robust lifecycle which is almost impossible to break.

There are clues too that *Plasmodiophora* may incorporate DNA from the host - perhaps a reason why biological control methods or genetically- induced protection methods have not yet been found. The traditional ways of controlling *Plasmodiophora*, either heavy liming (that is, adding quantities of calcium), alternative crop rotations or better soil drainage, similarly have only limited effect.

This is where boron comes in. The element is an essential plant nutrient, and it is well known that boron healthy plants are better able to resist disease causing organisms. In the case of brassicas, the important thing is to give the plant a head start, and certainly enough boron to begin with can help it resist clubroot.

But this doesn't fully explain why crops which enjoy good boron availability seem to be able to resist clubroot significantly better. Researchers, led by Professor Geoffrey Dixon of the Department of Bioscience and Biotechnology at the University of Strathclyde, Scotland, UK have been looking into this puzzle.

They started out with three possible ideas. Does boron somehow reduce the potency of the clubroot invader directly in the soil? Might it encourage the growth and activity of soil microbes which then prey on the *Plasmodiophora* before they attack? Or does it actually fight the invasion or its effects within the plant itself?

The team now suspects it is actually the latter. For boron, which contributes so much for so little to plant metabolism, seems not to do the same for the parasitic protozoan. Indeed it works in the opposite way and actually slows down the lifecycle.

What boron and, less strongly, calcium (from heavy liming) seem to do is to reduce the rate at which the invaders mature inside the root and turn into secondary sporangiophores - the ones that cause the damage - whose mission is to release new generations into the outside subterranean world. Boron apparently doesn't stop the initial invasion, but puts the harmful metamorphosis into slow motion.

Whether boron is altering the biochemical environment inside the root to make it *Plasmodiophora* unfriendly, or is encouraging the plant to retaliate is not yet clear. But the effect is the same. Brassicas are given more, and often enough time to mature and establish effective roots before clubroot tumors wreak their damage.

A 15-year long series of experiments conducted by the Strathclyde team has convincingly demonstrated that a specific application of boron to the seedlings at transplanting does indeed reduce the onset of clubroot symptoms and hence protects crop yields to a significant degree.

Species by species, brassicas vary in their susceptibility to boron deficiency, but generally they are rated as vulnerable to low boron levels for general growth and health: boron supplementation is, then, important anyway.

But the new message for growers is that, in the right amount and at the right time, it keeps clubroot in check.