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Helping the vegetable kingdom cope

Just how plants are able to lie low when conditions are tough has got clearer, says S.Ananthanarayanan.

Unlike animals, plants cannot move away from areas affected by floods or drought, but must cope or perish right where they are. How they do it is by switching metabolic processes on or off with the help of chemical signals that help processes to keep time with the environment. Masaru Tonokura and others at the University of Tokyo report advances in understanding just how the magic is worked.

Hormones

The chemical signals that control plant and animal processes are called ***hormones***, a word derived from the Greek for, 'set in motion'. Hormones are chemicals that living cells produce, in very small quantities, to affect the behaviour of themselves or of other cells. Hormones are thus highly specialised in their effect and they depend for their action on a specific feature in their molecular structure, which exactly fits a part, known as the 'receptor', of the target cell.

The effect of the hormone at the receptor is electric. The scale of response is quite disproportionate to the size of the stimulus – typical hormones in animals are insulin, testosterone, oestrogen, minute traces of which maintain the levels of sugar in the bloodstream or control the sexual characteristics of males and females. The action of hormones produced by the thyroid gland controls how fast the body burns energy, makes proteins, including the development of the brain, and also controls the sensitivity of other organs to different hormones. The action of the target cells may then affect the originator of the signal, to slow down, and this is often again through another hormone

The whole functioning of the body then depends on the correct production and transport of hormones. Hormones are typically produced and stored by different glands or types of cells and transported via the blood stream or through ducts, and to a limited extent from cell to cell.

Plants

Plants lack a system of blood circulation. They do have channels for the movement of water or minerals up the stem or of sugars down to the roots, but they do not have glands whose secretions could be stored and transported to different parts. And yet they need to influence the growth, development and differentiation of tissue, stems to reach up for air and sunshine, roots to reach down for water and nutrients and to produce leaves, flowers, seeds.

The hormones for plant development are hence produced not in localized glands but in all parts where needed. The hormones themselves are simple, so that they can diffuse within and between cells and also along the slower channels of fluid motion within the plant.

Phytohormones

This is the name given to hormones found in plants. As there is less communication between different parts of a plant, the production of plant hormones is less affected by the reaction of the target cells. The control at the targets then has to be through the nature of response of the targets themselves to hormones and this has evolved to depend on the stages of the target cells' development.

While the stages of development of cells is genetically controlled, the stages often do not coincide with the best environment. For instance, there may be a drought or frost and the dry or cold conditions are not the best for germination. As the cells are at that stage of development, the pant may hence perish, unless there is a way to slow down the germination process till conditions are better. There are similar needs when the plant is subjected to flooding or when it is better to delay seed maturation.

The control has been found to be through a class of plant hormones called ABA, or Abscisic Acid, the plant stress hormone. This is a class of "plant growth regulators", normally arising in the leaves when the plant is under stress, like drought or frost, and it acts by inhibiting leaf and bud growth and promoting seed dormancy. If it was not for ABA, buds and seeds would start to grow at the first warm period in winter and be killed when it got cold again. ABA dissipates slowly from the tissues and is able to delay premature growth. It accumulates within seeds during fruit maturation and helps prevent the seeds germinating within the fruit, or before conditions are right.

How do they work

The quantity of plant hormones required do their work is very small, just a millionth part of the hormone in solution. The result has been that it was very difficult to study how they go about promoting or inhibiting other processes. Their importance was discovered back in the 1880s but work had to be through study of genetically deficient plant strains or special cultures with controlled hormone exposure. Detailed investigation into their action has been possible only since the 1970s.

The recent work of Tanokura et al, reported in ***Nature***, has used modern analytical methods to work out the molecular mechanisms and the structure of the receptors for the ABA hormone, which inhibit processes in plants. The researchers have discovered the receptor PLY1, of which ABA is the regulator, and a protein ABA1, which is a negative regulator of ABA signalling, and a combination of ABA and PLY1, which are able to capture ABA1, the negative regulator.

The result is the possibility of a technique to control how ABA is inhibited and hence the metabolic processes in plants and thereby eliminate much loss, for instance of food crops through environmental instability.