Developing drought resistance in crop plants

High temperatures and shortage of water are major inhibitors of crop yield in many regions of the world. But scientists in Britain are achieving a better understanding of the mechanisms by which plants respond to such environmental stresses and this should aid the development of more tolerant varieties capable of growing more efficiently in hostile environments.

Under stress, plants rapidly produce proteins they do not normally possess under normal conditions. This type of mechanism is used in response to both heat-shock and drought, although the proteins involved are quite distinct.

The British research aims to identify the proteins and their mode of action, as well as the genetic basis of heat- and drought-tolerance. This information will be important in directing the future improvement of crops to cope with unfavourable conditions.

Scientists at the Agricultural and Food Research Council's (AFRC) Institute of Grassland and Environmental Research (IGER) are collaborating with researchers at the International Crops Research Institute for the Semi-Arid Tropics (ICFISAT) on the molecular basis of heat-tolerance in the small grain crops of millet and sorghum, which are the most important in the semi-arid tropics.

If exposed to high temperatures (>35¡C), sorghum and millet seedlings rapidly synthesise a specific set of proteins, known as heat-shock proteins (HSP). There is strong evidence that these are associated with tolerance to high temperatures.

The heat-sensitivity of seedlings relates to their ability to synthesise HSPs. Sorghum is at its most heat-sensitive in the first few hours of germination, when ability to make HSPs is at its lowest. In some millet varieties, the synthetic capability declines with age over the first 12 days after sowing, and those millet seedlings are most vulnerable to heat at 12 days.

Diagnostic Test

The research suggests that one reason why the HSP response is so rapid is that the RNA (ribonucleic acid) message coding for the proteins is already synthesised from the genes and is present "in readiness" inside dry seeds. The environmental conditions prevalent during seed maturation appear to modify subsequent thermotolerance, and the synthesis of the RNA coding for HSPs could be important in determining heat-sensitivity early in germination.

The scientists at IGER are developing a diagnostic test based on measuring HSP synthesis by immunological techniques. This will permit rapid screening and evaluation of the thermotolerance of different genotypes.

The research on drought-resistance shows that one of the most rapid biochemical events triggered by the onset of drought is the synthesis of abscissic acid (ABA), which is a key regulator of the plant's subsequent growth and development. Plants with a high capacity of accumulate ABA, exhibit improved water-use efficiency, which should benefit yield under drought.

Rice plants are among the fastest to accumulate ABA in response to water shortage. They can increase ABA concentrations more than 25-fold in two hours. Researchers at the AFRC Institute of Plant Science Research are identifying the protein synthesis associated with the early stages of drought response in rice.

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