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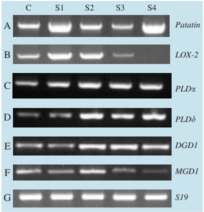

Lack of water leads to leaf lipid losses

When beset by potentially harmful environmental factors, plants are unable to uproot themselves and move away. Instead, they have evolved a remarkable range of tolerance and resistance mechanisms. This is well illustrated in the work of **Gigon *et al.* (University of Paris XII, pp. 345–351)** on the effects of drought stress in *Arabidopsis thaliana*. We do not think of this species as being especially drought-tolerant and yet, as shown by these authors, it can recover from periods of severe water deficit. Plants were subjected to water deficit by withholding irrigation; at intervals for the next 14 days, relative water content (RWC) and lipid content and composition were determined. As RWC declined so did leaf lipid content, reaching as low as 22.5 % of control levels at 17 % RWC (reached on day 14). However, different lipid classes were lost at different rates. In particular, the proportion of total lipids represented by phospholipids (PL) changed very little while the proportion represented by monogalactosyl (MG) lipids declined and that of digalactosyl (DG) lipids increased. Since galactosyl lipids only occur in plastids, this suggests that modification of plastid membrane lipids may occur during water deficit. The authors followed this up by assaying lipolytic activity and by monitoring expression of genes encoding enzymes involved in lipid metabolism. The ability of leaf extracts to degrade all three lipid classes increased with increasing water deficit, but MG-degrading activity increased the most whilst the increase in DG-degrading activity occurred later than the other two. There were also increases in the transcript levels of genes encoding lipolytic and phospholipase enzymes and, rather intriguingly, of at least one gene (digalactosyldiacylglycerol synthase) involved in DG synthesis. By contrast, expression of monogalactosyldiacylglycerol synthase, involved in MG synthesis, declined. Finally, and perhaps surprisingly, even the most drought-stressed of these plants, with a RWC of 17 %, recovered when re-watered and all these changes in lipid content and metabolism were reversed.

Larvae leave latecomer's leaves

It is often said that 'there's no such thing as a free lunch'. Equally we may say that there is no such thing as a free protection from being something else's lunch. Defence of plants against herbivory has an associated cost and in the 'cost–benefit analysis' imposed by natural selection that cost may sometimes be too high. There is an indication of this in the work of **Xiang and Chen (Mengla, China, pp. 377–384)**. They have looked at resistance to insectivorous herbivory in different species of *Ficus* that occupy different time-zones within an ecological succession. *Ficus hispida* is a pioneer, *F. auriculata* and *F. racemosa* are intermediate species and *F. altissima* is a late successional species. Vulnerability to herbivory was assayed by estimating damage sustained by seedlings in the field and by feeding leaves to caterpillars of the lepidopteran species *Asota caricae* (these caterpillars are natural predators of *Ficus* species). It has been suggested that pioneer species are often poorly defended because they allocate more resources to rapid growth and the authors' results support this view. The pioneer species *F. hispida* was indeed the most vulnerable and its leaves were highly palatable to the predator, while the late successional species *F. altissima* was the least vulnerable. The authors have used principal component analysis to examine the correlation between herbivory and particular plant characteristics. Vulnerability to herbivory was positively correlated with high leaf contents of N, Ca and P, with low leaf toughness, shorter leaf life-times and lower C : N ratios, all of which are characters of *F. hispida*. Strangely, leaf pubescence in this species had no deterrent effect on the caterpillars. At the other end of the scale, not only was *F. altissima* less vulnerable to predators, but if its leaves were attacked, synthesis of the anti-feedant Ca oxalate was induced and the leaves became tougher. This species commits a lot to defence!

Continued overleaf

Uptaking the P – it's the art of the soluble

I learned much of my early botany in the south-east of England. One of my abiding memories is the abrupt floral transition between the calcareous soils of the hills known as the North and South Downs and the more acid soils of the neighbouring ecosystems. Plants which favour limestone-derived soils are known as calcicoles while those avoiding such soils are known as calcifuges. The inability of calcifuges to grow well in calcareous habitats is based on several factors, from intolerance of excess calcium and/or of alkaline pH to a disruption in iron metabolism. However, there are still aspects of calcifuge physiology that are poorly understood. One of these is the relationship between calcium accumulation and phosphorus nutrition, which has been studied by **Angelika Zohlen and Germund Tyler at Lund, Sweden (pp. 427–432)**. They compared the growth of calcicole and calcifuge herbs and grasses in a mildly acidic non-calcareous soil and a calcareous soil; we concentrate here on the latter. Their results show clearly that growth of all the calcifuges, as measured by biomass accumulation, was markedly reduced when plants were on the calcareous soil. Chemical analysis of the plants showed that, on the calcareous soil, the calcifuge herbs had much lower concentrations of P than the calcicole herbs, suggesting an inhibition of P uptake. Further, a much smaller proportion of the total P was present as water-soluble Pi, i.e. a smaller proportion of a smaller total was available in the plant. The authors suggest that this results from a failure by the calcifuges to regulate Ca uptake from the calcareous soil, leading to the formation of Ca phosphate in the plant. However, this is clearly not the whole story because the calcifuge grasses, although exhibiting a similar growth inhibition to the herbs, suffered much less inhibition of P-uptake than the herbs and were able to maintain a much higher proportion of the P as water-soluble Pi.

ATP, PFK and CAM – an energetic look at an old story

Fluctuations in the acid content of the leaves of succulent plants – crassulacean acid metabolism (CAM) – were discovered a long time ago. The identification of the acid as malic acid and, in some species, its quantification over a day–night cycle were achieved early in the 20th century and since then it has been the subject of extensive research. However, there is still much that we do not know about CAM and it thus remains an interesting topic for study. This is exemplified by the work of **Chen and Nose (Fuzhou, China and Saga, Japan, pp. 449–455)**. They point out that, in terms of the source of carbohydrate used for malate synthesis, CAM plants fall into two general groups. One group, exemplified by *Kalanchoë* species, uses starch whilst the other, exemplified by *Ananas comosus* (pineapple), uses hexose sugar. This difference implies a difference in the expenditure of ATP per malate molecule and is also associated with differences in enzyme activities. *Kalanchoë* has a much higher activity of ATP-dependent phosphofructokinase than PPi-dependent phosphofructokinase; the reverse is true in *A. comosus*. The authors predicted that these differences should be reflected in differences in the content of 'energy-rich compounds'. Careful measurement of the relevant compounds during a day–night cycle confirmed this view. Both *Kalanchoë* and *Ananas* accumulated ATP in the dark and exhibited a higher adenylate energy charge (AEC) at night than during the day. However, the increases in ATP content and in AEC were greater in *Kalanchoë* than in *Ananas*, consistent with the view that, in ATP terms, starch is a less expensive source of carbon skeletons than hexose. However, a question remains. If indeed the use of hexose as a source of carbon skeletons for malate synthesis is more expensive than using starch, where does any selective advantage lie in using hexose? The ramifications of CAM are far from solved.

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