Plants adaptation to drought

Ammophila arenaria – marram grass

JM Cavanihac - France

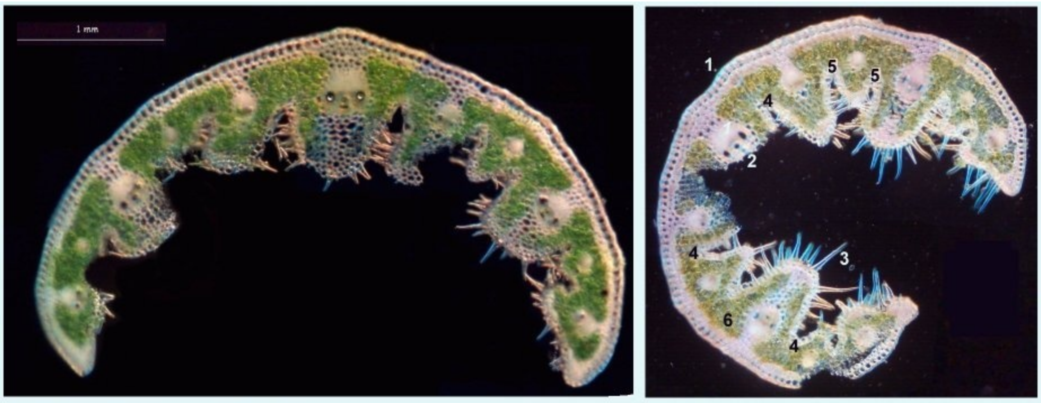
The spring of the year 2023 was marked by a severe drought in France due to a lack of rain. Fortunately, the summer was rainy, which made it possible to reduce the hygrology deficit, but this lack caused delays in the development of crops.

Important means are implemented to remedy these situations: water reserves constituted in autumn in anticipation, irrigation from boreholes... But the plants themselves have strategies to protect themselves from the lack of water.

There are "passive" strategies in plants accustomed to living in dry climates, whose leaves have changed over time to provide the least surface area for water evaporation; like lavender or thyme, or develop thorns like cacti.

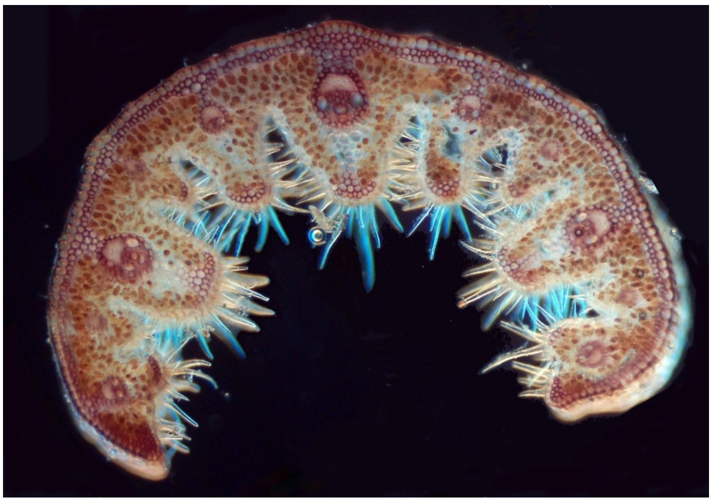
But there are also active strategies for climates or environments where the drought is not permanent: the plant modifies its geometry to present less surface facing the wind and the sun during its periods. This is the case of xerophytic plants

A fine example of this adaptation is the beachgrass, a Poaceae, plant of the wheat family, which is found by the sea, firmly anchored in the sand of dunes by deep roots. This particularity also allows the retention of the sand. During wet periods, the very thin leaf remains open but in lack of water the leaf rolls up on itself to protect its inner face: image on the left normal leaf, image on the right: leaf partially closed



1 thick epidermis **3 hairs** **5 crypt**
2 vascular bundle **4 stoma location** **6 chlorophylian tissue**

Another picture with red neutral staining and Rheinberg lighting:

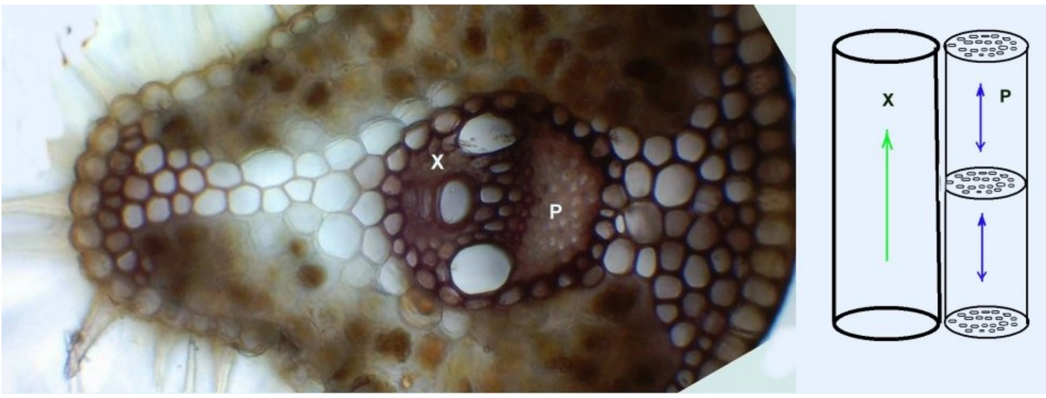


To understand this folding of the sheet you have to look at the bottom of the crypts "9":

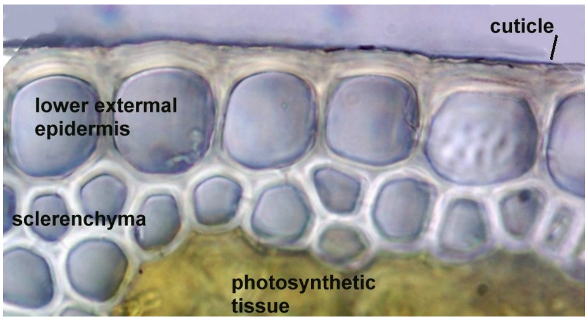
The hinge cells (3 below), when they are turgid cause the leaf to open. In the event of drought, their contents are emptied (plasmolysis), their size is reduced (flaccid) and the leaf contracts itself.
Another point limiting the loss of water is the position of the stomata, a few shown, number(1) and protected at the bottom of the crypts: In (2) open stomata. Stomata allow gas exchange: oxygen, CO2 and especially transpiration.

This mode of protection aims to allow the circulation of the sap, even if it is limited in the event of drought. Indeed, the xylem cells bring the raw sap coming from the roots and containing water and minerals, to the end of the leaves. Xylem (xylos means wood in Greek) is rich in lignin. It is the transpiration of the leaves that creates a call for water drawn by the roots. (90% of the water is rejected outside the leaves). *
The cells of the phloem (the name comes from the Greek word meaning “bark”) carry the elaborate sap, enriched with the carbohydrates that come from photosynthesis in the leaves. The phloem distributes them to all parts of the plant including the bottom and the roots through the cells with perforated walls, by gravity but also by diffusion: the circulation is bidirectional.

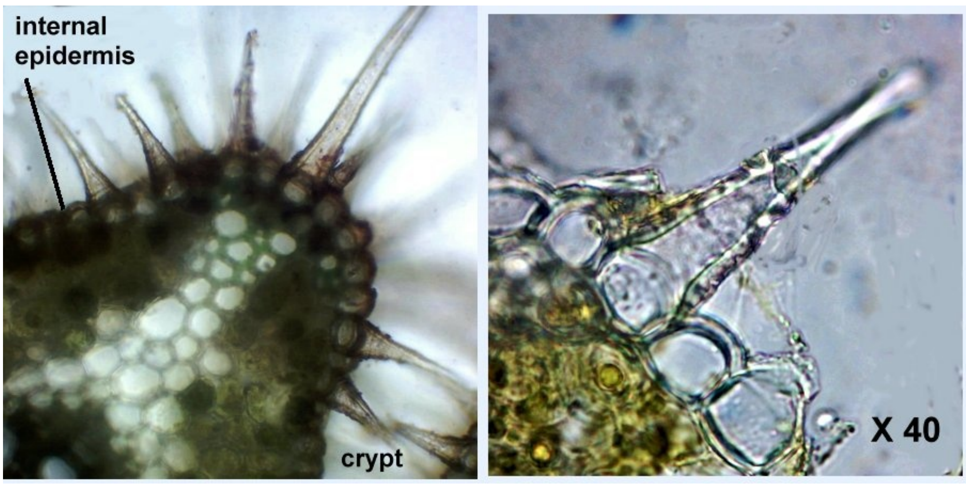
Colored image of the vascular bundle better showing the difference between xylem "X" cells (lignified and large wall tubes) and phloem "P" cells (smaller cells with perforated walls). Right diagram showing (in green) the movement of water and minerals in the xylem and in the phloem (in blue): elaborate sap to all parts of the plant.



The outer epidermis of the leaf helps to avoid drying out because it is thicker, waterproof and covered with a wax that prevents perspiration. The sclerenchyma made up of lignified tissues gives its rigidity to the leaf to resist the winds.



Finally another element of protection is the presence of hairs (trichomes) They are only present on the inner side of the leaf: right image detail of a hair at X 40 which appears hollow. The hairs impede the circulation of air in the rolled up leaf. They close the crypts by creating an environment that retains humidity.



This example of a sclerophyte plant is very didactic and included in many school books. It tries to illustrate all the parts of the plant that contribute to limiting water loss in a dynamic way since there is an effective movement.

As we have seen, marram grass is also used to make voluntary plantations to stabilize the dunes facing the sea, thanks to its extensive network of roots and rhizomes.

As a result, they are protected plants and their harvest is prohibited. However, the removal of a leaf or even a small piece of leaf broken by the wind (this is the case for this presentation) makes it possible to carry out the above observations and to sensitize the public, in particular young people, to the usefulness of these plants.

**Note:* the phenomenon of transpiration produces, by evaporation of the water, a cooling of the surface of the leaves and also of the surrounding environment. This is why more and more cities are developing green areas to help lower the local temperature in summer.

For more information:

https://www.researchgate.net/publication/318582965_Characteristics_of_marram_grass_Ammophila_arenaria_L_plant_of_the_coastal_dunes_of_the_Mediterranean_Eastern_Morocco_Ecological_morpho-anatomical_and_physiological_aspects

http://bahsintegratedscience.weebly.com/transport-in-plants.html

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Published in the September 2023 issue of *Micscape* magazine.
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