Back to the roots

Gymnasium Koeniz-Lerbermatt - 16ei

1. Theory

Plant roots have several functions: they anchor and stabilise the plant, they supply it with water, nutrients and minerals they absorb from the ground. Also, they are used to store the energy produced by photosynthesis in form of carbohydrates and proteins, as such as carrots or potatoes, which can be used as aliments.(3) Activities in roots are characterised by osmosis and diffusion, using semipermeable membranes, and are therefore able to describe e.g. soil quality.

Types of roots
Taproots: The primary root becomes the largest root of the plant.
Fibrous root system: The primary root doesn't grow especially large, in exchange there are lots of small roots, developing directly from the stem rather than from other roots.

In some species the energy storing part can grow very large, which is increased by breeding in order to eat them. Such plants are e.g. sugar beet, potatoes, beetroots and radish.(4) Instead of directly eating them, in our culture, they are mostly sold, bought and sold again, which makes the roots a point of ecological interest. Otherwise they are used to control the soil erosion or to propagate the plants.(3)

"Roots are selective about which minerals they absorb." (1) Some minerals are more important than others. They fulfil special functions. (1)

Structure
In the core of the root the *vascular system*, one of the main parts, is situated. It consists out of *xylem* and *phloem*. The function of the xylem is to conduct water and minerals from the roots into all other parts of the plant. The phloem's function in contrast is to distribute products of photosynthesis in the hole plant and therefore into the roots. There, the energy is used for root's growth in the *meristematic zone*. This tissue is located at all the root tips and consists of undifferentiated cells which then develop to their final function. This meristem is protected by the *root cap*. On the other side the energy is stored in the *cortex*, a structure surrounding the vascular system, separated from it by the *endodermis*. On the outside it's separated from the soil by the *epidermis*, which also grows the *root hairs*. Those enlarge the surface of the root enormously, which is essential for water and mineral uptake.(3)

Water and dissolved minerals enter the root tip of a root hair with endothermic activities. On different ways, either through a plant's symplast or apoplast (illustration 1), they travel to the root cylinder in the centre of root. The casparian strip makes that the ions have to pass at least one cell membrane. By passing through the cell membrane, they are sorted out by osmosis. After having entered the root cylinder, they can't get out anymore. This way, there is a higher concentration of minerals in the root than in the soil solution. This leads to the root pressure. (2)
In the xylem, water and dissolved ions are finally pulled up into the plant. The power for this phenomenon is mainly provided the transpirational pull. During the night, when the plant's transpiration isn't active owing to photosynthesis, the root's pressure is sometimes that high, that the xylem essence is pushed up anyway. Then, little drops of dew appear on the leaf's edges of little plants. (2)

2. Material & Methods

For our experiment we used cress seed, Petri dishes, object plate holder, filter paper and water with different concentrations of salinity.

For our project ideas we first collected all possible ideas in a mind map. We decided to select two projects to be assured to have a plan B if our first choice failed. Afterwards we voted which two projects we could do, considering the time and resources we had. We divided our class in two small groups. We sat together to talk about how to setup the experiments. We started both experiments at the same time but one of them failed so we perpetuated only the project regarding the compatibility of our roots with different salinity.

We mixed water with different concentrations of salt. The seedlings were put on a filter paper which we put in Petri dishes. The dishes were then put in the object plate holders. The first twelve seedlings we put in normal tap water. This procedure is going on with 1g per litre, 5g per litre and 10g per litre.

Our hypothesis was that the salinity of the water has an effect on the growth of the roots.
For this experiment, the independent variable was the salinity concentration of the water. The dependant variable was the growth of the roots. The controlled variables were light, temperature and air humidity which were constant.
From this point, the seedlings just had to grow, and we measured the roots.

For the main project we changed the different salinities. We wanted to know with how much dissolved NaCl a plant can still exist. We assumed the seedling to fold by the concentration of 10g per litre. But they didn't, and so we decided to reinforce the concentrations. We took normal tap water, 5g per litre, 10g per litre, 15g per litre and 20g per litre as concentrations. The rest of the experiment was the same as described.

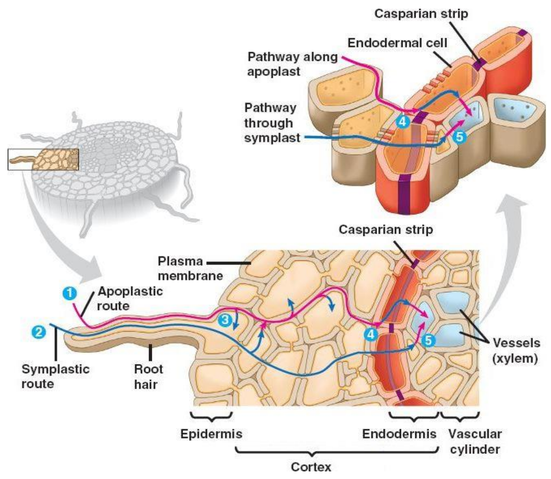

Illustration 1(5): apoplast and symplast pathway

Illustration 2: Dew guttation

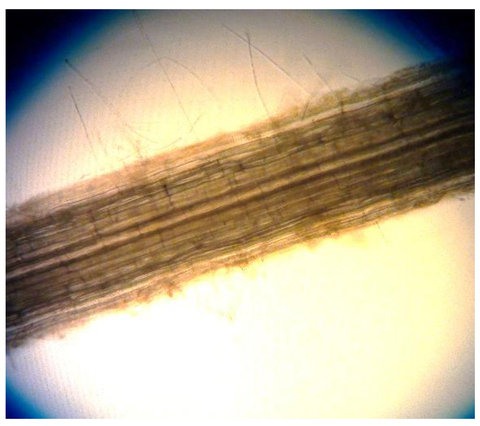

Illustration 3: Root under the light optical microscope

Illustration 4: Our root lab

3. Results

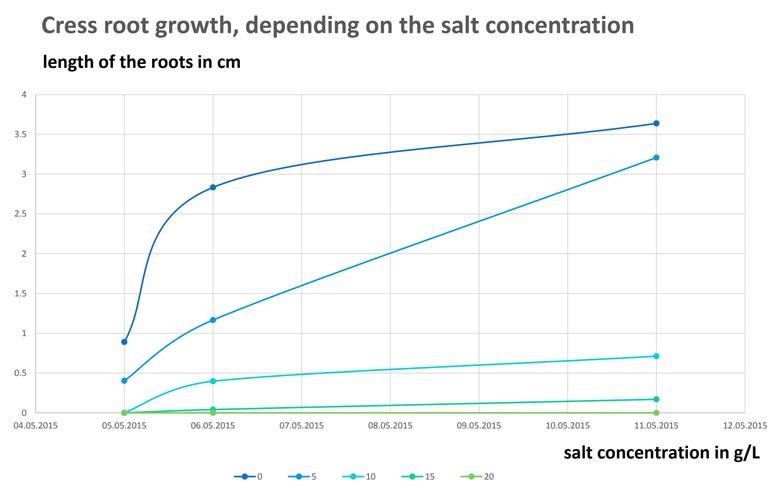

Diagram with the results of our experiment. On the x-axis is the length of the roots and on the y-axis are the days of measurement. The colored lines are the different concentrations.

In this diagram our data is shown. The cresses watered with water without any salinity grew very fast. Also the ones with the salinity concentration of 5 grew fast, but the ones with the concentrations of 10, 15 and 20 had some problems. In the end the cresses with concentrations of 10 and 15 grew a little bit. The cresses with the salinity concentration of 20 couldn't grow. The standard deviation varies between 0 and 2.86.
In the first two days the growth of the cresses rose sharply, then it decreased. Only the one with the concentration of 5 rose continuously.

4. Discussion

Now that we have the results, we see that our hypothesis is right: The different salt concentrations have indeed an effect on the growing of the roots. The more salt is in the water, the less the cress grows. So now we can analyse with the theory what exactly happened with the plants.

We think that the growing depends on osmosis. The water absorption is caused by the different concentrations of the ions, inside and outside the cells. If these concentrations aren't the same, the water tries to balance the concentration gradient through the semipermeable membrane. Because of this pressure and the other mechanisms, like transpiration, the plant is able to absorb the water.

In our experiment we saw that this procedure worked properly at low salt concentrations, so the plants didn't have problems to grow.

On the other hand, the roots didn't grow at a salt concentration of 20g per litre and rarely grew at the concentration of 15g per litre.

Therefore, our conclusion is that normally the salt concentration in the root bark of the cress is 15 to 20g per litre. If the concentration of ions is about the same in- and outside of the root bark cells, the water does not diffuse. But if the concentration outside the cells is higher than inside, the water flows out of the seed. This scenario happens at the amount of 20g per litre. With this thesis we can explain why the roots won't grow.

Otherwise the seeds budded almost as well with the concentration of 5g per litre as if we didn't add any salt.

Evaluation:
All in all, we think that the experiment worked well. The experiment setup was quite easy to handle, we didn't have much work to do. The measurement of the roots was a good method to gain data. But this could also be a source of errors like false ratings, because we only used a normal ruler. On the other hand, we collected a big amount of data to minimise little mistakes. Another weakness of the experiment could be a wrong weighing of the salt, so the concentrations wouldn't be exactly enough. What is more, maybe the seeds on one object plate didn't get an equal amount of salt and water, because of the filter paper.

Improving the investigation:
For a next investigation at this type it would be good to use distilled water aswell. In this way we would have a NaCl concentration of zero. Also we could try out other filter paper, to see if there's a difference in growth. Next, to gain more precise data we could use salt concentration with smaller difference in between, for example: 1 g/l, 2 g/l, 3 g/l and so on

Sources

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