Rootgrowth and electric current

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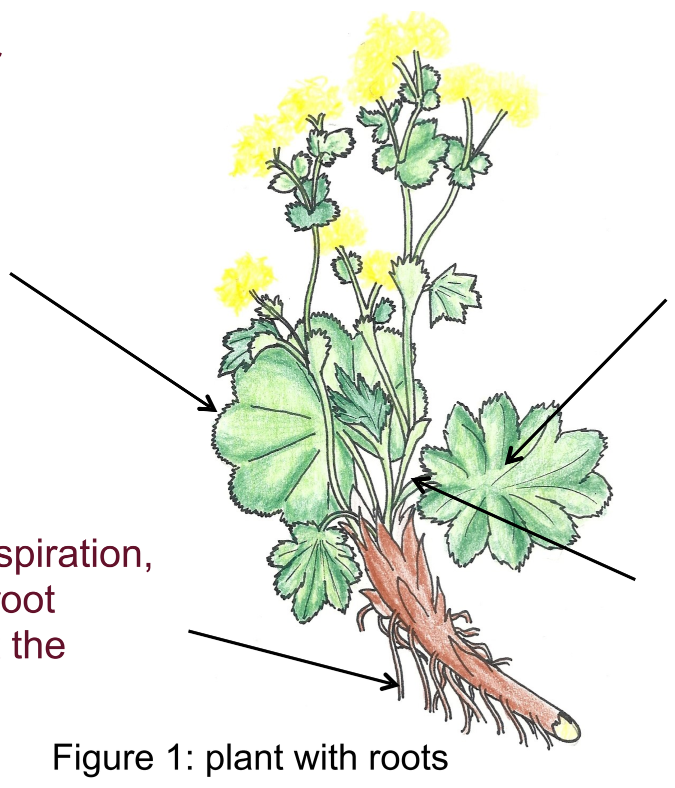
Transpiration and Guttation with the e.g. *Alchemilla*

Guttation:
If the plant has higher water potential as the environment and she can't make transpiration, the plant loses constantly water through the

Transpiration:
If the plant has a higher water potential as the environment, the plant loses water through the Stomata. The water evaporates.[1]



Root pressure:
If there isn't any transpiration, the roots produce a root pressure to transport the water to the top.[1]

Suction effect:
To transport the water to the leaves, the stem develops a suction effect to transport the water upwards.[1]

Figure 1: plant with roots

When the water potential in the roots is lower than the water potential in the ground, the root hairs absorb water and Ions.

Roots in science

Plants under current:
Generally roots have to take up nutrients as ions. The plant has to gather them against the concentration gradient. Since Ions are moved, charged particulate material is also being moved. This needs energy and we see a connection to electricity. To transport the solute material the roots have special carriers. The gathered ions degrades the water potential on the inner side of the root epidermis and the water is able to flow without using more energy. An increase of transpiration enables a higher transport of ions. [2]

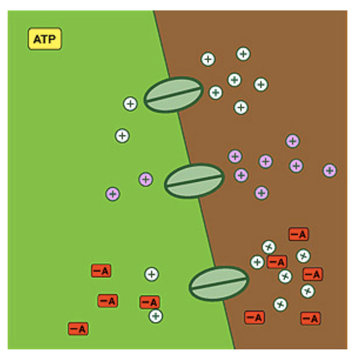


Figure 2: Ion transports in roots [2]

Hypothesis

Our hypothesis was that the electric field has an influence to the growth of roots.
Voltage was the independant variable of our experiment.

Description of the Experiment

Because of the salts which the plants need to survive, we talked about ions and we had the thought that electricity is nothing else different than electrically charged particles.
So the idea came up, that we could put the plants under electric current. As test plants we used five day old radishes because we found out that they grow fast.
To begin the experiment we had to figure out how to lead the electric power as good as possible to our plants. The easiest way was by filling in a medium [3] into some petri dishes and then drill in some holes for the graphite staffs. After that, we connected the staffs with electric cables, so that the current could flow through the medium.
On the backside of the petri dishes, we sticked a film with a millimeter grill on it. Then we retraced the roots on the film. We repeated this every two days, but with different colours.

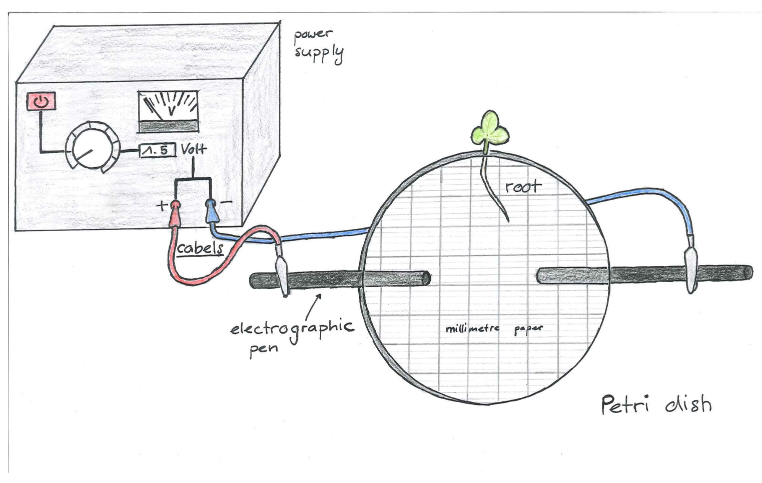


Figure 3: experiment set-up

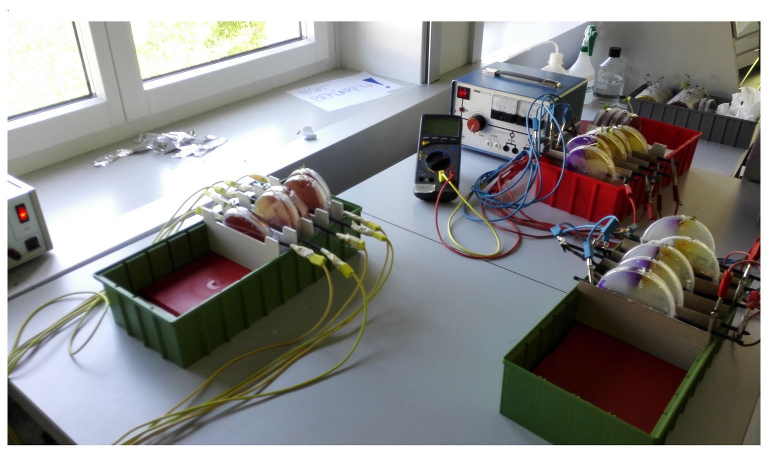
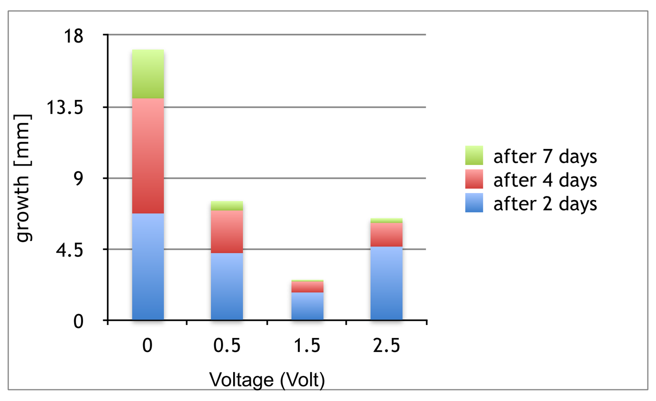


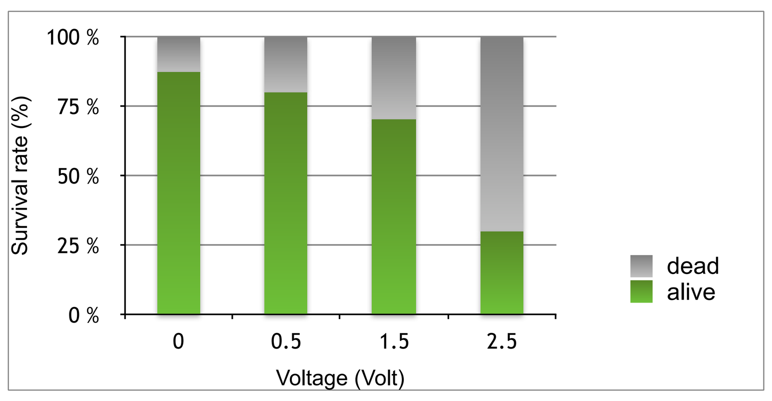
Figure 4: experiment set-up

Results

We made our experiment two times with five plants for each force of current. De Graph 1 shows the data we collected from all our 40 plants. As we recognize, the plants, which were exposed to current grow at much lower speed and stayed small. Also, over time, the grow rate of the exposed plants decreased. The result of the current wasn't that great at the beginning, but in the 4th and 7th day it got visible quite well, this was also due to the higher mortality rate of the plants under current. This we displayed in Graph 2 To the difference in the results of 1.5 V and 2.5 V we can only say that it's natural. There were some plants growing very well at 2.5 and some dying at 1.5 V right away.
Although are measurements may vary one millimeter more or less it doesnt't change the significants of our results.



Graph 1: growth of the roots



Graph 2: death rate after seven days

Conclusion

Figure 5: survey of the PH values (first line 0V, second 0.5V, third 1.5V, fourth 2.5V)

After collecting and comparing the data, we found out that the plants, which were exposed to higher current would die more likely than the ones exposed to lower current. We also saw a much higher difference in the PH-values in the nutrient media exposed to 2.5 V and 1.5 V than in the ones exposed to 0.5 V or 0 V, this has to do with the electrolysis happening at the electrodes (Figure 5, 6, 7). In our pictures you can clearly see our indicator, the bromocresol purple. This indicator is yellow in a PH-value below 5.2 and purple above 6.8. As a result of the electrolysis, there should be a accumulation of positive ions at the anode and negative ions at the cathode. As we know, plants are only able to gather their nutrients if they are in a ionized form. So in the effect of this, we assume that there is a accumulation of nutrients at both poles, but only of a positive or negative charge, not a mixture of both. The roots which grow to one pole only get ions of one charge and lack the ones with the other charge. The roots which grow in the middle have a lack of both charges, because the ions tend to diffuse to the poles. As a consequence of the lack or the overspill of nutrients the plants can't grow at a normal rate or even die. These were also the results in a study about Lupinus albus[4].

Figure 6: coloration of the indicator, 1.5V

Figure 7: no coloration of the indicator, 0V

Sources

Sources:

1. Eduard Strasburger: Lehrbuch der Botanik 32.Auflage, neubearbeitet von v.Denffer•Ziegler•Ehrendorfer•Bresinsky, Gustav Fischer Verlag, P. 312 - 328
2. http://www.uni-duesseldorf.de/MathNat/Biologie/Didaktik/Wasserhaushalt/dateien/4_von_w/1_wurzel/dateien/3_ionen.html, 11.05.15
3. Keil M., Kremer B. 2004, Wenn Monster munter werden, Rhizosphäere, p 105, Wiley, Weinheim
4. Pflügers Archiv, European Journal of Physiology, 1925, Volume 210, Issue 1, pp 392-405

Picture sources:

Figure 1: drawn by Nathalie Brugger
Figure 3: drawn by Moses Aouami
Figure 4: photography by Wiebke VanBeurden
Figure 5: photography by Cedric Messmer
Figure 6: photography by Cedric Messmer
Figure 7: photography by Cedric Messmer
Graph 1: made by Marina Signer
Graph 2: made by Marina Signer