

The Mystery Of Auxin

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Task 2

Transpiration & Guttation

Roots in sciences. Why may they be of interest in respect of physiology, biochemistry and economy?

The three basic organs of plants are roots, stem axis and leaf constitute. The roots are an aphyllous organ. The major task of the roots are anchor, support plants and absorb and conduct water and minerals in soil. The roots store products of photosynthesis (carbohydrates, sugars). The roots have four zones, the root cap, the zone of cell division, the zone of elongation and the zone of maturation.

The essential plant mineral nutrient elements that are absorbed by plant roots exist in the soil solution as ions. The cations will adsorb by the soil colloid (rude dispersed soil particles and negative loaded). The anions underlie the eluviation more than the cations. That means that the plants must detach the minerals out of the soil. This process is an active transport. The most important ions are only findable until a pH of 5.

One important reason for bad growing results are compressed grounds. They prevent surplus water from seeping away sufficiently, the roots can not spread until the deep soil and the plant dry out and die because of water deficiency. Economically important is that the farmer protect the soil by loosening up. The vegetable or the cereal grows better and the farmers can harvest more yield.

Root growth and development

Metabolism, development and growth of plants are regulated by hormones. Auxins are a class of plant hormones. These plant growth substances are the best known. The most important auxin is that occurring anywhere in the plant indole-3-acetic acid (IAA). This is the most potent native auxin.

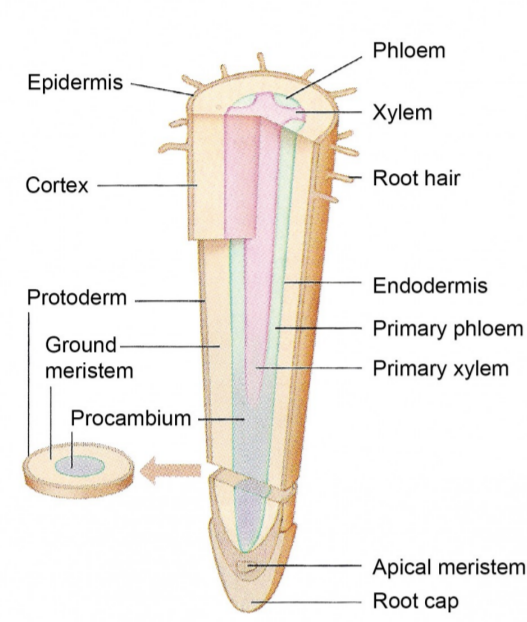


Fig. 1: Sketch of a root

The roots hair function is to increase the area of absorption of the root. The epidermis protect the root and absorb water and dissolved ions. The cortex store foods reserve. The xylem transports water and dissolved substances from the soil upward in plant roots and stems. The phloem transports organic substances from the leaves to the roots. (Fig. 1)

How is dew formation (guttation) connected to activities in roots?

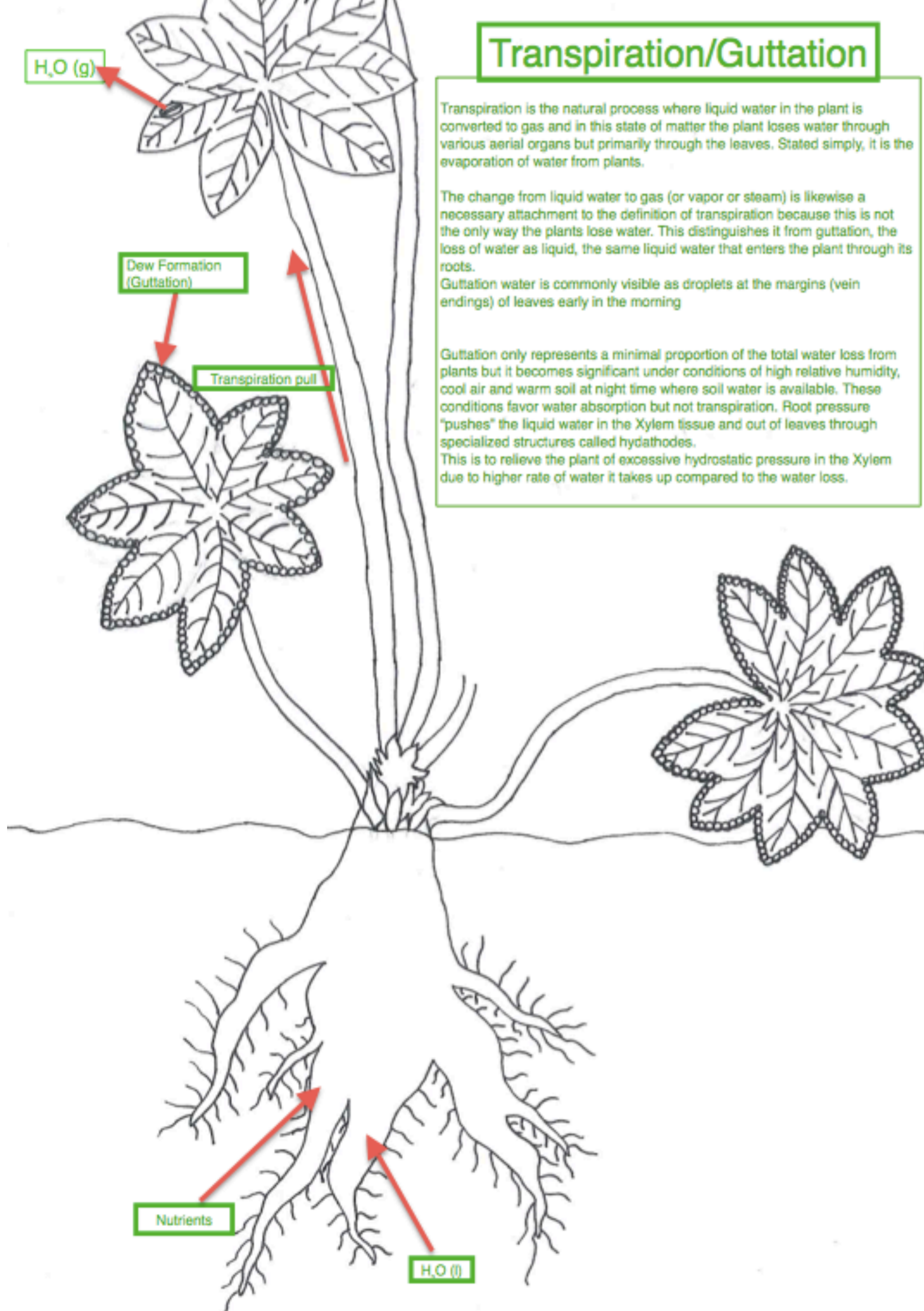


Fig. 2: Explanation of transpiration / guttation and a drawing

Different concentration/types of auxin

How do different concentrations/types of auxin influence the increase of the roots/stems?

The effect of auxin in plants:

Auxin promotes the cell growth and elongation of the plant. In the elongation process, auxin changes the plant wall's plasticity making it easier for the plant to grow upwards. Auxin also influences rooting formations, promotes the gutting from tree buds and the fast growing of new shoots. In addition, the rate of cell division in cambium raises, the cytoplasmic streaming gets promoted and the fruit ripening gets delayed. Through the agent influx changes the multi endocrine system in the cells. According to the concentration of auxin, the various areas (the bud, the stem and the roots) are affected differently. ²

Hypothesis

Based on our research we expect that the roots will grow more/get longer with 10^{-9} mg/ml auxin in the culture medium but the stem increase will be inhibited with this concentration. On the opposite we expect that the stem will raise more with 10^{-6} mg/ml auxin in the culture medium but the root increase will be inhibited. In addition we think that the influence will be bigger with indole-3-butyric acid than with indole-3-acetic acid.

Method: Experiment

For our experiment we used one-week-old radish shoots because radish germinate fast and their roots are stronger than those of cress. We made a culture medium out of a loading solution³ with the indicator "Bromkresolpurpur" and thickened it with 0,4 or 1 % agar. To this, we added plant-based (indole-3-acetic acid) and synthetic (indole-3-butyric acid) auxin in different concentrations (no auxin; 10^{-9} mg/ml auxin; 10^{-6} mg/ml auxin). After creating our culture medium we poured it in Petri dishes. Then we measured the stem and marked the length of the roots. We stored the Petri dishes upright in a box in a room with room temperature and daylight. From that time on we observed the plants and measured the increase of the roots and the stem.

Our measurement technology: We placed a thin wire against the root and the stem and measured the length on a ruler. We found out that there is an error rate of 2.1 mm by letting ten people measure the same stem and calculated the differences of the average value (which is not that bad because we have high numbers).

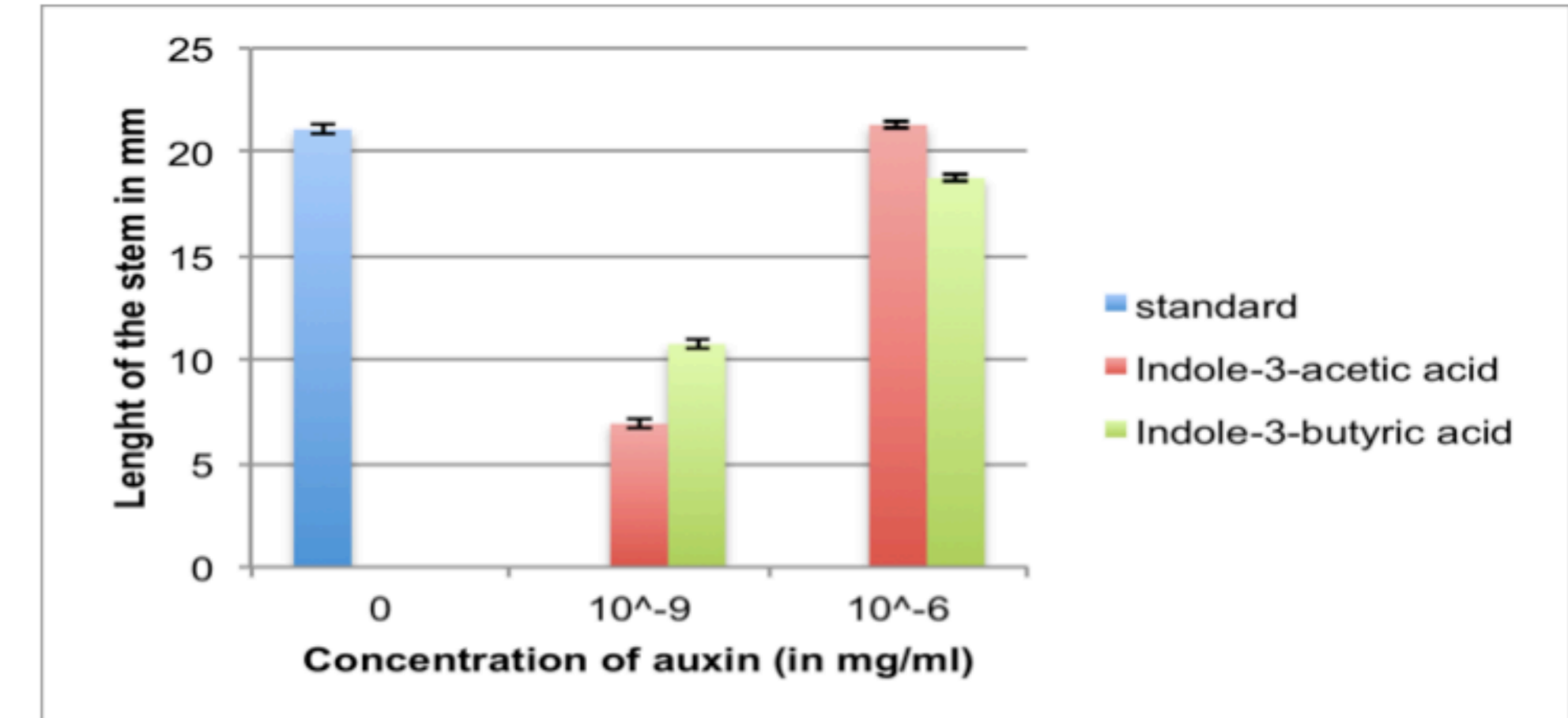


Fig. 6: Increase of stems after six days, due to different auxin concentrations; average value n=6
The diagram shows that the lower concentration of the acid doesn't promote the growth of the stem very much. The higher concentration has nearly the same length as the 0 concentration. You also see a difference between the lower and the higher concentration of auxin. At the concentration of 10^{-9} mg/ml the indole-3-butyric acid has a bigger influence on the increase than the indole-3-acetic acid. At the concentration of 10^{-6} auxin, it is the total opposite.

The error rate of 2.1mm is also shown in both graphs.

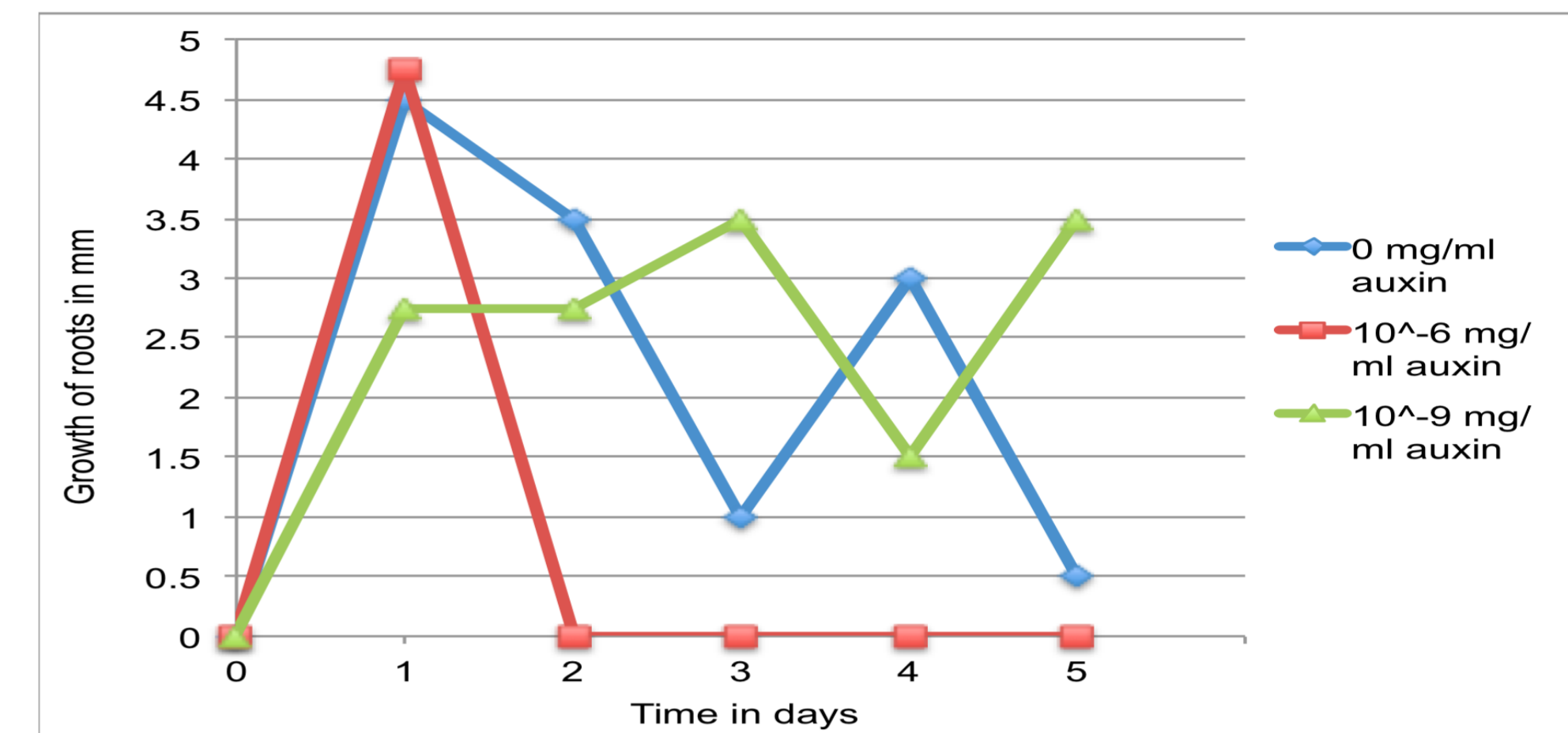


Fig. 7: Increase of roots depending duration; average value n=4

This graphic shows us how the roots of radishes grow without any influence of hormones and how they grow with influence of two different concentrations of auxin. In the graphic you can see that the roots with the bigger concentration of auxin just grew on the first day and afterwards the roots didn't grow any more. On the graph of the roots with lower concentration of auxin and on the graph without auxin the roots grew each day and not only one day how it is shown on the graph of the roots with the higher concentration of auxin. Conspicuous is also day five where just the roots with the lower concentration of auxin grew a lot in contrast to the two other graphs of roots.

Interpretations

Interpretation of the graphs about the increase of roots/stems due different auxin concentrations:

As you can see in our graph the roots grew more or less like our expectations based on literature³ we found about the fact that low concentration (10^{-9} mg/ml) auxin promotes the longitudinal growth of roots and inhibits the growth of the stem and in high concentration (10^{-6} mg/ml) the growth of the stem gets supported and the growth of the roots gets inhibited. The only change of increase, which doesn't correspond to the theory is the average of the roots with 10^{-9} mg/ml Indole-3-acetic acid, because it isn't high enough. Our explanation is that we had one plant which didn't grow and was nearly dead. When we neglect this plant, we had an average of 46.2 mm, which is a bit higher. It's also strange that the average of increase of roots without auxin grew the most but here we also had one freak value, whose roots grew 273mm. When we neglect this root the average of the other five is 10.9mm.

Another thing our data collection shows is the huge difference between plant-based and synthetic auxin, it is said that synthetic auxin has a stronger influence. We can see this in our graphs: at the concentration of 10^{-9} mg/ml the indole-3-butyric acid has a bigger influence on the root and the stem. By contrast at the concentration of 10^{-6} mg/ml the indole-3-acetic acid is more relevant.

Interpretation of the graph about the increase of roots depending duration:

In this graphic we can see that auxin influences the growth of roots in a positive way. The red line has a high increase on the first day but on the other days there is no more growth. We conclude that there was too much auxin which had a negative effect on the growth of the roots. They grew too much on the first day what was not good for the roots. The green line has the highest average growth of the roots of those three lines. To sum up, in our experiment we can see that a low concentration of auxin is helpful for the growth of roots but if the concentration is too high it is not helpful at all.

Interpretation of the pH changes:

The indicator Bromocresol purple showed an acid change and colored the agar yellow. We suppose that the higher concentration of 10^{-6} mg/ml auxin in the agar, led to a forced uptake of Ammonium and in consequence to a higher H_3O^+ -ion output into the rhizosphere and an increase of the H_3O^+ -concentration in the agar base.

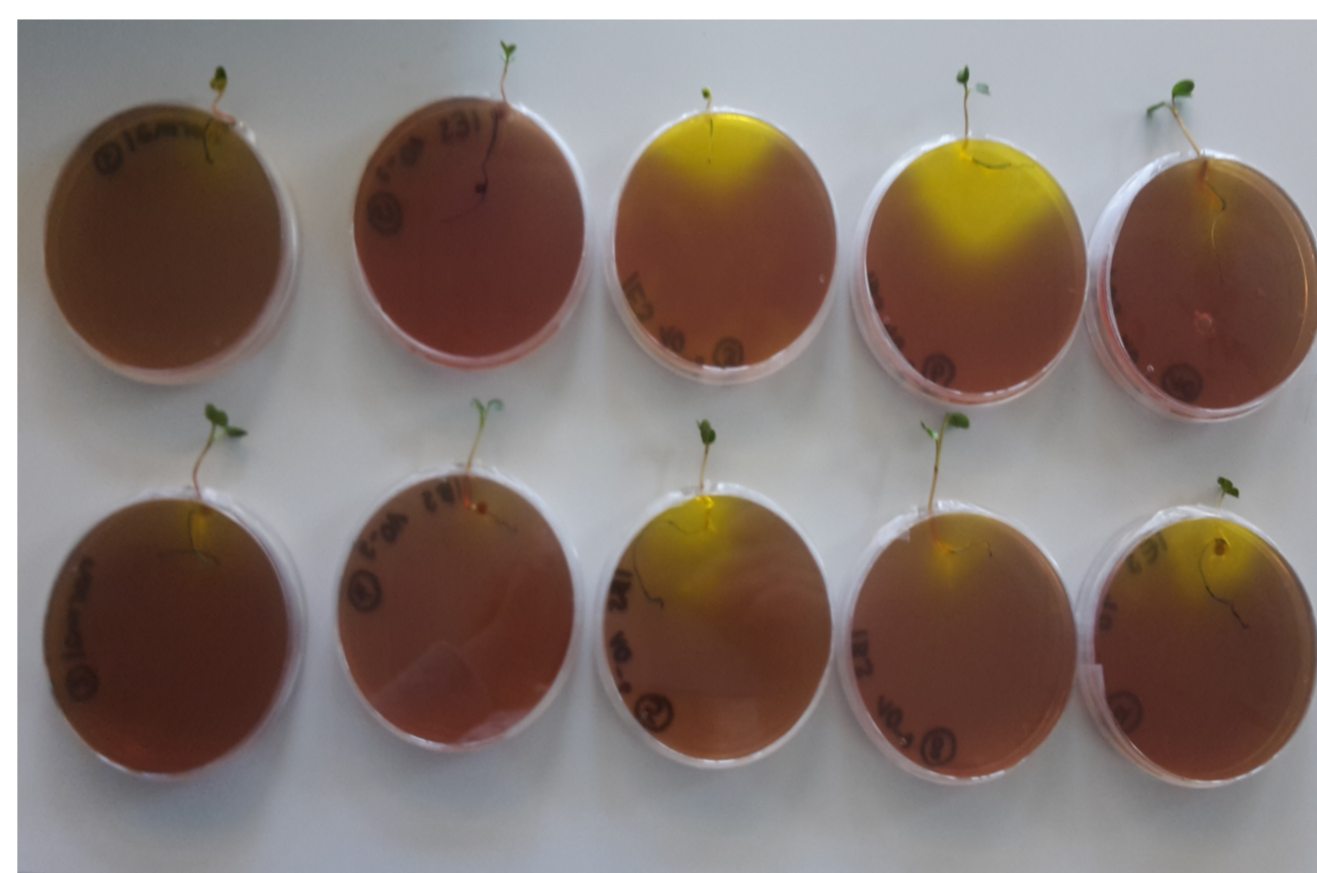


Fig. 3: Roots in different agar

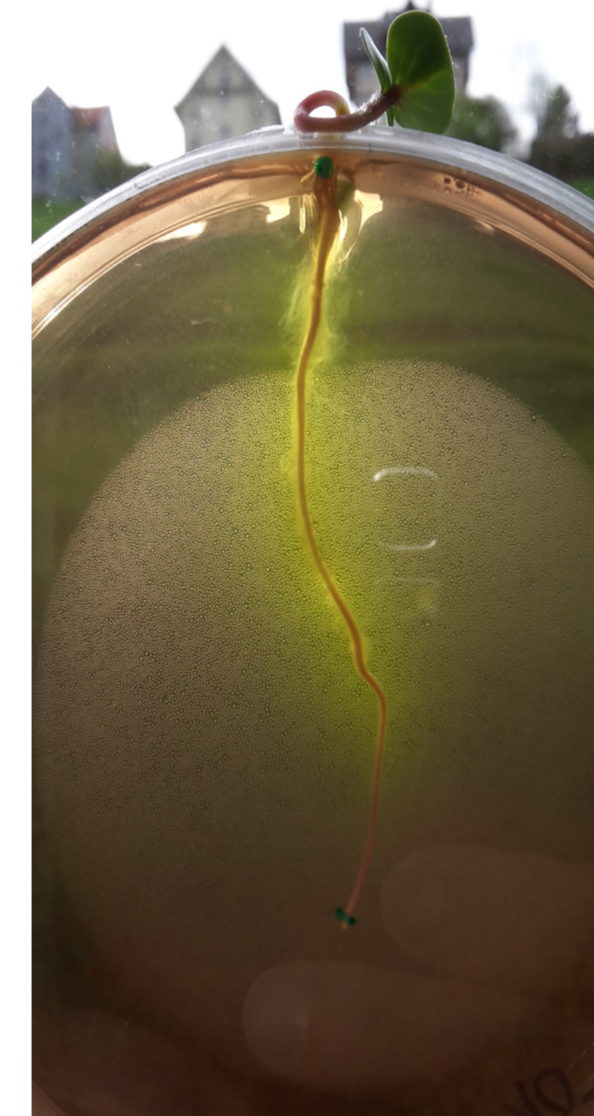


Fig. 4: Root

Explanation with graphs

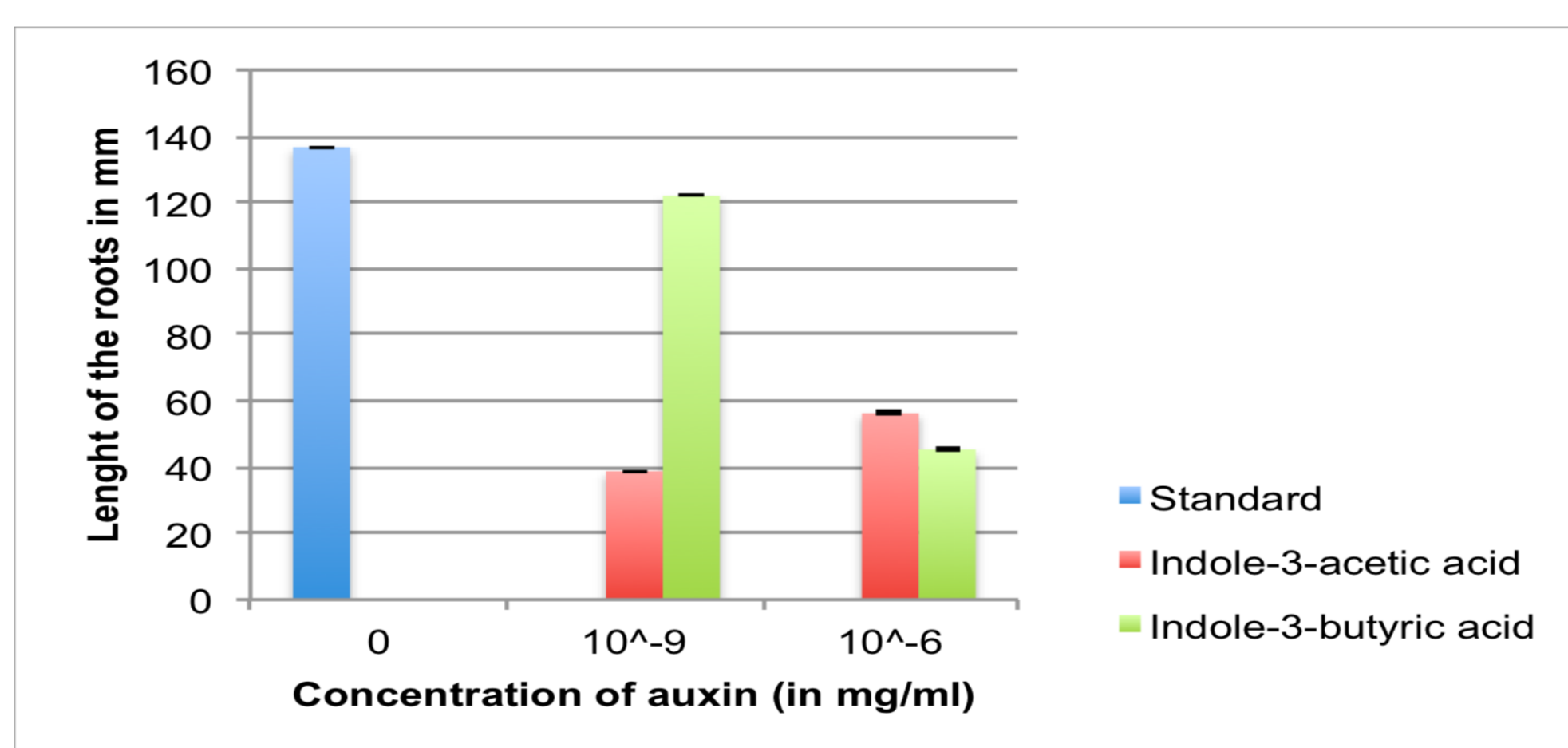


Fig. 5: Increase of roots after six days, due to different auxin concentrations; average value n=6

Due to the diagram we could see that the root generally doesn't grow that well with any additional concentration of auxin. The only thing different is by the lower concentration of indole-3-butyric acid the roots grow significantly more than in comparison of the other acids.

Reference List:

Figure sources:

- Fig. 1: https://online.science.psu.edu/biol011_sandbox_7239/node/7463, retrieved May 4, 2015
- Fig. 2: Self-made
- Fig. 3-4: Picture taken from us
- Fig. 5-7: Self-made graph
- Fig. 8: Self-made drawing

Internet sources:

- ¹ <http://bankofbiology.blogspot.ch/2014/07/differences-between-transpiration-and.html>, retrieved April 22, 2015
- ² <http://www.zum.de/Faecher/Materialien/beck/12/bs12-51.htm>, retrieved May 12, 2015

Literature sources:

- ³ Keil, M., Kremer, B. et al. 2004. Wenn Monster munter werden, Rhizosphäre, p 105. Wiley, Weinheim
- ⁴ Jansen, H.1969. Wuchs-und Hemmstoffe im Gartenbau. Hef119. pp 22-26/87-91. Eugen Ulmer Verlag.