

Abstract

Plants are known to adjust the orientation of their organs, shoot and root, to ensure maximal energy generation and nutrient uptake, but also to avoid toxic growth conditions. Directional growth regulation depends on asymmetric plant organ growth and it is crucial to ensure plant survival. It is orchestrated on cellular level in concert with exogenous and intrinsic signals. Even though tropistic growth responses of plants were described by Darwin on macroscopic level already in 1880, now it is necessary to understand molecular mechanisms that underpin efficient modulation of directional plant growth.

During my studies I focused on factors that modulate directional root growth regulation. The root is a complex, three-dimensional object, which continuously modifies its shape and growth path. Since the root needs to expand its surface to supply the plant with nutrients and water, it is important to understand how roots cope with changing growth conditions while exploring the soil. If the root cannot manage to grow through soil efficiently, mechanical impedance and lack of resources will also restrict shoot growth as well. Manifold signaling pathways coordinate the complex processes that underpin efficient root growth, including those modulated by phytohormones, sugars, flavonoids and other metabolites. Detailed mechanistic studies of how those signaling cascades are interconnected on subcellular level are still partly missing. Previously published studies showed that the key molecular players, which are responsible for the asymmetric distribution of auxin, often called a morphogen, delimit directional root growth and speed depending on growth conditions, including changing energy supply. On molecular level, auxin distribution is controlled through precise regulation of localization, abundance and activity of auxin carriers.

My thesis consists of published articles that demonstrate on one side the importance of molecular regulation of a proteins involved in auxin distribution and thereby modulation of root growth. Furthermore, I showed how the inability to steer directional root growth in mutants with delimited auxin distribution in roots impairs the roots' ability to react to exogenous growth conditions. My research allowed to describe the importance of two highly conserved cysteines in the protein sequence of the auxin transporter PIN-FORMED 2, which determine the protein abundance and subcellular distribution. This results in different root waving pattern, which reflects the difficulty of the root to compensate deviation of root growth that occurs when a root is grown on the surface of agar supplemented growth medium. The intensive study of root growth dynamics further resulted in a better understanding of how cultivation conditions affect orchestration of directional root growth. Therefore, in my follow-up publications I described the relationship between exogenous signals and auxin dependent modulation of directional root growth by observing root growth responses of mutants lacking either a well-studied plasma membrane located auxin importers or exporters.

Finally, I contributed to two studies that dissect the interplay of efficient actin cytoskeleton assembly and auxin homeostasis for proper root growth. I am highly interested in establishing novel methods to enhance the sensitivity of mass-spectrometric analysis of phytohormonal metabolism. I measured and evaluated the differences of hormone metabolism in mutants (i), lacking a central modulator of actin branching, ARP2/3 complex, and (ii), a mutant with altered phospholipid content that lacks two phosphatidylinositol 4-kinases.

In summary, my efforts allowed to further dissect levels of directional root growth regulation, which is highly dependent on fine-tuned auxin distribution and signaling in the root tip.