
The Effects of Compaction on Plant Roots

And the Plants That Can Help Mitigate Compaction

Addressing Compaction

When integrating regenerative principles into growing strategies, it is possible to be quickly faced with the prospect of reducing tillage in the fields. This is because compaction can occur as a result of heavy tillage. This is good motivation to seek a better understanding of the processes involved in creating compaction as well as strategies to overcome high tillage processes. In this section, take a look at the root response to compaction and learn about some plants that can be integrated to help with this serious issue.

The Impacts of Compaction

Compaction can happen in both topsoil and subsoils, as well as at the surface of the soil. Because farm equipment is getting heavier, there is an increased risk of chronic subsoil compaction. As soil becomes more compacted, roots require more strength to push deeper into the soil profile. Roots tend to become thicker and develop longer root hairs, and this helps with resource acquisition and root tip penetration in compacted soil.

The Product of Ethylene

Roots sense soil compaction via the buildup of ethylene in the rhizosphere. Ethylene is produced by the roots and engages in normal gas exchanging with the atmosphere. However, ethylene accumulation at the root tips triggers abscisic acid and auxin as downstream signals to regulate root adaptive responses in compacted soil. Ethylene promotes lignification (formation of rigid and woody structures) of outer cortical cells, providing mechanical stability for penetration in compacted soil. Ethylene also helps regulate the navigation strategies of root tips when encountering mechanical obstacles.

The Effect of Compaction on Water Infiltration

Compaction can reduce water infiltration capacity and water storage capacity while increasing water runoff events. In runoff events, gas exchange with the atmosphere becomes limited. If oxygen consumption is higher than supply, it can lead to anaerobic conditions in the soil, which can lead to a reduction of soil organisms, including earthworms. Soil compaction sets off negative cascading effects (i.e., reduced soil quality, soil respiration, water and nutrient availability, potential increase of phytotoxins, etc.).

Root Sensing of Compaction

Roots are extremely sensitive to compaction. In certain scenarios, compaction can induce severe root growth reduction, suppression of branching, root hair elongation, crown root number enhancement, and thickening of roots. When roots try to penetrate a compaction zone, there is a buildup of the gaseous hormone ethylene. This is due to reduced gas exchange in the soil which triggers a buildup of ethylene in the rhizosphere. This buildup can activate the endogenous ethylene signaling pathway at the root tip. Restricted ethylene diffusion -- not mechanical forces -- are the primary signal.

Root Response to High Concentrations of Ethylene in Rhizosphere

Auxin accumulates in the root epidermal cells which inhibits root growth. Abscisic acid (ABA) serves as an essential regulator in response to soil compaction, and it increases root diameter. Recent research suggests that multiseriate cortical sclerenchyma (MCS) is a set of highly-lignified outer cortical cells that enhance mechanical support for root penetration of compacted soil by increasing tensile strength and root tip resilience. MCS has been found in heritage varieties of maize, wheat and barley and is considered a vital downstream output of ethylene.

Circumnutation

Circumnutation is the helical movement of the root tip and is a proposed action of the root tip to navigate obstacles. Ethylene, auxin and cytokinin are thought to be primarily responsible for this. Circumnutation enables bypassing of hard obstacles and is especially evident with young plants, like seedlings.

Strategically Reducing Compaction

Soil compaction can be mitigated through strategic plant choices and management practices that enhance soil structure, increase organic matter, and promote biological activity. Plants can be added to cash crops via under-seeding, intercropping and polycropping systems. Cover cropping is also an effective way of incorporating plants that can reduce hardpan while adding organic matter and increasing microbial activity.

Plants that Help Reduce Compaction

Deep roots: These plants can help with compaction as they are well-suited to dig deep into the soil with their tap roots. They include daikon radish, tillage radish, alfalfa and chicory.

Fibrous roots: These plants, like ryegrass and sudan grass, have dense roots that can help stabilize the soil while providing organic matter.

Brassicas: Some brassicas, such as forage turnip that has a taproot, and mustard that has deep roots, also help with compaction.

Using Functional Groups to Reduce Compaction

Using functional groups in combination with one another is an important way to obtain maximum benefit when dealing with compaction. It allows for a synergistic relationship with the plants involved while improving soil function. With the knowledge shared in the previous slide, the hope is that you may be inspired to find other plants to include in your seed mixes that work in your context.

Conclusion

Roots are a critical function of a plant's resiliency and ability to adapt to the environment. We have learned how roots respond to environmental stresses like heat waves, flooding and compacted soil. Throughout this document, it has also become apparent that soil organic matter and soil biology have a symbiotic relationship with roots. By obtaining a more complete picture of plant function, we can modify management practices to better tackle our changing landscapes.

Thank you for reading.