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ROOT PHENOTYPING

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ABSTRACT

The root system is the key component of the plants. It not only anchors the plants in soil but also supplies required minerals and water to the plants. Due to this function, it may strongly affect the plant yield. An optimized root system according to the growing conditions results into sustainable plant production. Root properties play a great role in governing traits like moisture stress tolerance, nutrient use efficiency, yield etc. Root phenotyping enables to identify the phenotypic changes in plants during different growth stages with the robotic system through high throughput screening.

INTRODUCTION

Currently, the worldwide research community focuses more on the roots, growing, and how their spatial and temporal changes occur during whole plant cycles. Due to strict standard, technological interventions, and collaborations root phenomics got prominence. Phenomics emphasizing on measuring and studying phenotypes – an exciting landscape of new research strategies with the introduction of image-based phenotyping and artificial intelligence. In phenotypic studies researchers studies the root images and quantify the properties of the root system.

ROOT SYSTEM ARCHITECTURE (RSA)

Roots play different functions, viz; uptake of water and nutrients, forming symbioses with rhizospheric microorganisms, anchoring the plant and also loading organs. The root architecture and its shape and structure govern the interaction of the plants with their environment. The root anatomically consists of the xylem, the phloem, and the pericycle, named stele (Smith and De Smet, 2012). There are two types of roots: (i) The primary and seminal roots (Hochholdinger, 2009) (ii) Adventitious roots (ARs). The elongation, growth angles from the central axis, lateral branching, and longevity of all root classes form the root system determined by genetic, physiological, and environmental factors (Lynch and Brown, 2012).

Root system architectures varies based on plant type (monocot/dicot). The primary root system and also laterals develop into the basic structure in the dicots whereas in monocot develop adventitious root system which extends from stem of the plants. The head of the roots in dicot plant grow well due to cell division in the secondary growth stages.

Root systems are composite framework of the different elemental blocks of cells which are organized in a large network to work together. Hence, the root system helps to develop the concept of phene. Describing the individual/ organism or an organ like root system based on its external features is referred to as phenotype. Phenes are defined as individually measurable components of the phenotype; phene is to the gene as the phenotype is to genotype. In order to study the root system, everything relates to roots may categorically divided into four phenes:

1) Root geometry
2) Root morphology
3) Root topology
4) Growth and development of roots

ANALYSIS OF ROOT SYSTEM ARCHITECTURE IMAGES

Similar to root image acquisition, the analysis of root images often results in a trade-off between the complexity of the images, the level of detail of the extracted data, and the level of automation of the software tool. While assessing the root images to study the root phenology two major problems occurs:

1) Overlapping of the roots with each other
2) Crossing of the roots with each other while growing into the soils.

Thus, it makes really difficult to identify the growing and branching pattern of the roots inside the soil. In those situations, employing the complete root architecture can me very useful that can extract the images of the roots from plants. The images may be capture by two ways:

a) Semi-automated solutions
b) Fully automated systems

Semi-automated solutions are based on manual processing the root where the roots divides into correction and click based categories. In correction-based categories images are analysed followed by the correction steps whereas click based system individual roots are analysed even for complex root structures, provided no time constraint. In conditions where large number of images of the roots need to be analysed and geometric and morphological information need to collected. These tools are used to study the genotypic and phenotypic information of the root architecture for the root system development in the plants (Fig. 1).

The analysis tools must be chosen keeping in view the primary question need to be answered. For example, if we are willing to identify the effect of any fertilizer on the branching pattern of the plants then there is need to deeply study the root architecture image.

CONCLUSION

With the growing population, focused research on roots can significantly close the yield gap. Therefore, acquiring root data and its meaningful inferences is the need of the hour. This root information will be available in the public domain with image-based root phenotyping, image analysis, computer vision, and machine learning. Root system architecture information will lead to breeding more water-efficient varieties in the future to feed the world.

REFERENCES

Bao, Y., Aggarwal, P., Robbins, N.E., Sturrock, C.J., Thompson, M.C., Tan, H.Q., Tham, C., Duan, L., Rodriguez, P.L., Vernoux, T. and Mooney, S.J., 2014. Plant roots use a patterning mechanism to position lateral root branches toward available water. *Proceedings of the National Academy of Sciences*, **111**(25): 9319-9324.

Smith S., and De Smet I. 2012. Root system architecture: insights from *Arabidopsis* and cereal crops. *Philosophical Transactions of the Royal Society B: Biological Sciences* **36** (7): 1441–1452

Hochholdinger F. 2009. The Maize Root System: morphology, Anatomy, and Genetics. *In*: Handbook of Maize: Its Biology eds Bennetzen J. L., Hake S. C., editors. (New York, NY: Springer) 145–160.

Lynch J. P., and Brown K. M. (2012). New roots for agriculture: exploiting the root phenome. *Philosophical Transactions of the Royal Society B: Biological Sciences* **36** (7): 1598–1604.

Lynch J. 1995. Root architecture and plant productivity. *Plant Physiology* 109: 7–13. 10.1104/pp.109.1.7

Villordon A. Q., Firon N., Clark C. A., and Smith A. 2014a. Manipulating Root System Architecture in Sweet potato for Global Food Security: Progress Prospects and Applications. Paper Presented at the Society for Experimental Biology meeting, Roots for Global Food Security session, Manchester

Larry York and Guillaume Lobet. 2017. Phenomics of root system architecture: Measuring and analyzing root phenes, *Plant cell* pp1-9.

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