Assisted Plant Breeding With Computer Models: Improving The Links Between Root Traits And Plant Growth.

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Introduction

Roots have many important roles: they provide anchorage in the soil and they acquire resources necessary for plant subsistence, roots also influence plant growth and development with the production of several plant growth regulators (Waisel et al 1991). Because of their location underground, and the numerous interactions with the soil and the microorganisms, the study of the roots is a challenge that has inherent methodological difficulties. Computer models could be of great benefit to increase the understanding of the processes that take place at root level, helping researchers and plant breeders in the selection of the most important traits that can increase plant productivity (Wullschleger et al 1994).

Plant and root models

Those plants that are more efficient in the use of energy and carbon by the root can explore more soil and extract more resources. Moreover, plants with better root architecture have also an advantage in the acquisition of elements, like phosphorus, that are distributed mainly on the topsoil and that are obtained mainly by diffusion in the soil (Lynch and Brown 2001).

At this moment several root-growth models are available, these can describe in detail the architecture, distribution and carbon-costs of different roots (Lynch et al. 1997; Somma et al. 1998; Pagès et al. 2000; Dunbabin et al. 2002).

Several plant-growth models have been developed in the last 30 years. Based on plant parameters and climate data as rainfall or temperature, they can estimate carbon assimilation and finally plant productivity. But despite its strength in the simulation of canopy-level processes, these models suffer of an over-simplification of the way in which the root is described (Hoogenboom 1999).

Working Hypothesis

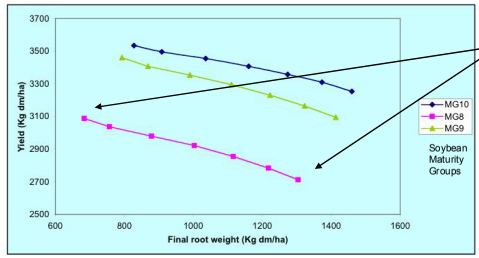
We propose that there is an opportunity to link these two type of models and gain a better understanding of the effects of carbon efficiency utilization on productivity. Specifically, we are working in a communication link between the root growth model SimRoot (Lynch et al 1997) and the crop growth model CROPGRO Boote et al 1998).

The main variable to be sent from CROPGRO will be the amount of carbon allocated to the root. SimRoot will return to CROPGRO the distribution of the root in the soil and the amount of phosphorus acquired, and CROPGRO will calculate water uptake and any change in plant canopy

References

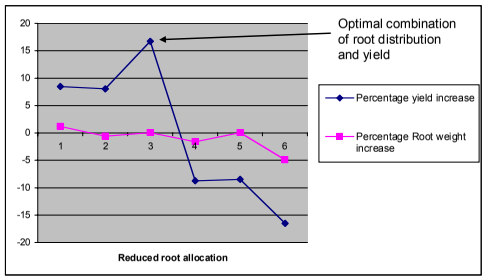
Waisel Y. et al 1991, *Plant Roots the Hidden Half*; Wullschleger S.D. et al 1994, *Plant and Soil* 165:149-160; Lynch J.P. and Brown K.M. 2001, *Plant and Soil* 237:225-237. Lynch J.P. et al 1997, *Plant and Soil* 188:139-151; Somma F. et al 1998, *Plant and Soil* 202:281-293: Pagès et al. 200, *Root Methods a Handbook 113-146;* Dunbabin et al. 2002, *Plant and Soil* 239:19-38; Hoogenboom G. 1999, *Acta Horticulturae 507:241-251*; Boote K.J. et al 1996, *Agronomy Journal* 88:704-716.

Preliminary Results



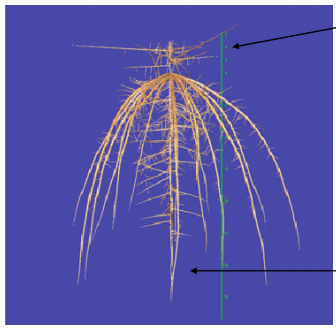
A decrease on the amount of dry mass in the root can increase the potential yield (the one not affected by any limitation)

Potential yield of soybean Maturity Groups adapted to low-latitude environments. This CRPGRO simulation was based on weather information from Guandong Province



This effect cancels out when water stress is taken into account. A smaller root means a higher risk of water stress

Note that CROPGRO does not show a rapid reduction on root weight as the plant tries to increase the size of its root when water stress occurs. At the end yield is greatly affected as we force a smaller root.



Adventitious roots increase phosphorus acquisition, and have an smaller maintenance cost

With SimRoot it is possible to explore scenarios of root-optimization combining the cost of each root type and root architecture.

A deep taproot increases water uptake.

Future Activities

- We are merging these two models to provide a tool to study the tradeoffs on root efficiency.
- Experimentation will be required to obtain parameters on the specific varieties that have been selected in the MF project.

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