Water Use Efficiency in Potato

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Abstract

Water is one of the key resources challenging the sustainability of modern agriculture. In developing countries, potato production is increasing because of its ability to provide nutritious food in a short season. However, the potato crop requires profuse irrigation. Yields of commercial potato varieties are often restricted by water availability. Their root systems are generally sparse and shallow, and they close their stomata, preventing photosynthetic carbon assimilation, whilst water is still available in the soil. To enable breeding of drought tolerant varieties, we are developing phenotype screens that will allow us to explore the genetic basis of key traits for water use efficiency (WUE). From field trials of a genetic mapping population, ten genotypes with contrasting transpiration efficiencies based on leaf δ13C values were cultivated under controlled glasshouse conditions. After emergence, plants were grown for 30 days in soils watered to field capacity (30% volumetric content, 5 kPa water potential) before being divided into three groups irrigated to 30% (−300 kPa, slight stress) and 12% (−1500 kPa, wilting point) volumetric content. As WUE is a complex phenomenon, we evaluated a number of associated physiological and morphological traits. Tissue samples were also collected at different time points to determine differentially expressed genes at these moisture levels. Response to water stress not only includes closing stomata but also reducing the density of stomata during leaf development. Preliminary data from our experiments shows that transpiration-efficient genotypes, as indicated by low leaf δ13C values, have consistently lower stomatal conductance at 12% volumetric soil moisture than transpiration-inefficient genotypes. Thus transpiration-inefficient genotypes transpire more water at lower soil water content.

Introduction

- Water is an inherent constituent of all metabolic processes for plant growth and development.
- Hydrological and cropping systems are affected by climate change.
- Increased intensity of weather events.
- Deforestation and Population pressure.
- Dependency on water has become a critical constraint to agriculture development and food security, the great challenge for coming decades is to increase food production with limited water.

Materials & Methods

Ten genotypes with contrasting behavior for δ13C measurements from 12601 x Stirling population chosen from previous year’s field trials.

Genotypes were cultivated under controlled glasshouse conditions in 12” pots at three moisture levels. Figure represents the moisture levels ofbullion field soil packed at 1200kg/m³.

Plants grown for 36 days at field capacity (30% volumetric content, 5 kPa water potential) and divided into three groups (irrigated to: 1) 30%, 2) 20% (−300 kPa, slight stress) and 3) 12% (−1500 kPa, wilting point) volumetric content. Measurements/samples collected on days 36 (control), day 56 and day 76.

Results

Stomatal conductance depends on stomatal density and size. Counting the stomatal density illustrates that stomatal number are significantly different between genotypes and programs shows that stomatal density per unit area increases with decreasing moisture levels.

Figures showing the relationship between field Delta carbon values to the pot δ13C on day 36 after emergence. Preliminary data represented as graphical shows that transpiration-efficient genotypes, as indicated by low leaf δ13C values, have consistently lower stomatal conductance at 12% volumetric soil moisture than transpiration-inefficient genotypes. Thus transpiration-inefficient genotypes transpire more water at lower soil water content.

References:


FAO, 2007