

Evaluation of high yielding soybean germplasm under water limitation

Silvas J. Prince, Mackensie Murphy, Raymond N. Mutava, Zhengzhi Zhang, Na Nguyen, Yoon Ha Kim, Safiullah M. Pathan, Grover J. Shannon, Babu Valliyodan and Henry T. Nguyen*

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Abstract Limited information is available for soybean root traits and their plasticity under drought stress. To date, no studies have focused on examining diverse soybean germplasm for regulation of shoot and root response under water limited conditions across varying soil types. In this study, 17 genetically diverse soybean germplasm lines were selected to study root response to water limited conditions in clay (trial 1) and sandy soil (trial 2) in two target environments. Physiological data on shoot traits was measured at multiple crop stages ranging from early vegetative to pod filling. The phenotypic root traits, and biomass accumulation data are collected at pod filling stage. In trial 1, the number of lateral roots and forks were positively correlated with plot yield under water limitation and in trial 2, lateral root thickness was positively correlated with the hill plot yield. Plant introduction (PI) 578477A and 088444 were found to have higher later root number and forks in clay soil with higher

yield under water limitation. In sandy soil, PI458020 was found to have a thicker lateral root system and higher yield under water limitation. The genotypes identified in this study could be used to enhance drought tolerance of elite soybean cultivars through improved root traits specific to target environments.

Keywords: Fibrous root; root angle; root plasticity; root system architecture (RSA); root thickness; spectral indices; soybean; spectral indices; total root length; water limitation

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INTRODUCTION

Soybean has been established as an important crop for oil, animal feed, and its human nutritional applications worldwide. It is imperative for the immediate improvement of drought tolerance and avoidance traits to enhance seed quality and reduce yield losses (Kedihun 1997; Abenavoli et al. 2012). Root traits contribute to drought avoidance of plants, which is relevant to avoid agricultural drought and sustain crop performance (Serraj et al. 2011). Crop plant root system architecture (RSA) influences grain yields and optimizes agricultural land use (Smith and De smet 2003). Roots traits are crucial in maintaining crop yields in soils suffering from insufficient water and nutrients (Bengough et al. 2011). Many scientists have also claimed that the modification of root system architecture will achieve a new green revolution and provide enhanced crop yields (De Dornodot et al. 2007; Lynch 2007; Den Hender et al. 2010). This will also aid in the adaptation of crops to water limited environments and having plants with improved water use efficiency leading to enhanced crop productivity (Mutava et al. 2015). Although the importance of RSA has been known for decades, the complex nature of the trait and interactions with external factors, made it impossible to select for in field conditions (Prince et al. 2015).

The occurrence of drought stress during flowering/early pod filling stages in soybean increases the rate of lower abortion and causes yield loss (Westgate and Peterson 1993; Liu et al. 2003). It also alters the root morphology, volume, and

weight, which ultimately diminishes the crop yield (Liang et al. 2014). In addition, it favors increase in lateral root length, number and root hairs that increase total root surface area for improved water uptake (Nielsen et al. 1997; Osmond et al. 2007). Thus, studying root architectural traits and the response in water limited environments is critical to increase soybean productivity in drought conditions. In most crop plants, genetic variations exist for RSA, which enables successful mapping of quantitative trait loci (QTLs) and identification of genes associated with root traits (Prince et al. 2015). Most root studies in soybean have utilized bi-parental mapping populations to map QTLs for root traits in the seedling stage in controlled greenhouse conditions (Liang et al. 2010; Zhou et al. 2010; Brensha et al. 2012; Liang et al. 2014; Manavalan et al. 2015; Prince et al. 2015) with the exception of a study aimed at mapping QTLs for fibrous root score for plants grown in the field (Abdel-Haleem et al. 2011). Studying root traits of mature plants is important due to varied responses to soil and climatic conditions when compared to the seedling stage in controlled conditions (Watt et al. 2013). A better understanding of the different elements of RSA such as root elongation rate, rooting angle, lateral root branching, and longevity is essential to enhance the efficiency of crop breeding programs by utilizing root traits (Lynch and Brown 2012).

Deeper and longer roots play a crucial role in water uptake from deeper soils. Deeper rooting is a complex trait that is affected by growth angle and total root length in cereal crops

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