Root System Architecture Analysis of Sorghum Genotypes and Its Effect on Drought Adaptation

Authors: Hailemariam Solomon, Taye Tadesse, Daniel Nadew, Firezer Girma

Abstract: Sorghum is a crucial crop in semi-arid regions because of its capacity to resume photosynthesis and physiological growth after being subjected to drought stress. Although it is one of the most resilient crops to drought stress, recurrent drought is affecting its productivity. It is thus of paramount importance to explore genes contributing to drought stress adaptation, thereby increasing the productivity of sorghum. A study was initiated to evaluate and determine the effect of root systems, particularly root angle traits, on drought stress adaptation and grain yield performance. A total of 428 sorghum genotypes from the Ethiopian breeding program were evaluated for their performance in three drought-stress environments. The experimental materials include stay-green, non-stay-green genotypes and released sorghum varieties. A row-column design with three replications was used for the field trials. A high-throughput phenotyping platform and a row-column design with two replications were used for root system traits. The mean grain yield for non-stay green genotypes ranged from 1.63 to 3.1 tons/ha. However, for stay-green genotypes, it ranged from 2.4 to 2.9 tons per ha. The analysis of the root system architecture showed highly significant variations among the genotypes. The root angle of non-stay-green genotypes ranged from 8.0 to 30.5 degrees, while for stay-green sorghum genotypes it varied from 12.0 to 29.0 degrees. At the same time, for improved varieties, it exhibited between 14.04 and 19.50 degrees. The result of the principal component for stay-green genotypes was computed, and the largest variations were 52.7% and the least were 10.4%. The most contributing traits in dimension one were shoot dry weight and shoot fresh weight, followed by leaf width and shoot length. Positive and significant correlations were observed between leaf areas and shoot dry weight and leaf width and shoot dry weight at phenotypic and genotypic levels. Negative correlations were observed between root angle and leaf area. Root angle and root length traits had a negative phenotypic correlation (r = -0.018). In conclusion, in drought-stressed conditions, narrow root angle genotypes produced the highest grain production. Therefore, narrow root angle genotypes should be taken into account in sorghum breeding to boost the highest grain production in drought-stressed areas. Secondly, the association of the narrow root angle trait with grain yield revealed a connection between the two traits to maximize the productivity of sorghum, both for stay-green and non-stay-green sorghum genotypes. However, the productivity of narrow root angle genotypes was higher for stay-green gene introgressed sorghum genotypes. Finally, the negative correlation obtained between the root angle and grain yield traits for stay-green genotypes has justified the possibility of using the stay-green trait to select sorghum genotypes with narrow root angles.

Keywords: root system architecture, root angle, narrow root angle, wider root angle, drought

Conference Title: ICPS 2025: International Conference on Plant Sciences

Conference Location: Toronto, Canada

Conference Dates: June 15-16, 2025