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Drought Stress in Tropical Maize: The Genetic Dissection of Key Traits in Multiple Environments

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Abstract

There is evidence that the global mean temperatures are increasing and the climate is becoming more erratic. Certain tropical and subtropical regions will particularly suffer from the drawbacks of higher temperature and reduced rainfall. Understanding the drought response of maize is a key to developing more drought tolerant cultivars that help ensuring food security.

To dissect the genetic basis of drought tolerance with a special emphasis on QTL-by-environment interactions (QEI), a recombinant inbred line population of sub-Saharan provenance was evaluated in nine field experiments representing four environments: water stress at flowering and well-watered conditions in Mexico and Zimbabwe. The non-linear, negative relationship between the anthesis to silking interval (ASI) and grain yield (GY) across water regimes and locations was observed, although the segregation of GY was larger in Zimbabwe compared to Mexico, whereas secondary traits were more important in Mexico. Besides calculating experiment-specific QTLs, joint QTL analyses were conducted per environment, per water regime across locations and across all experiments. The number of QTLs identified for male flowering time, ASI, GY, kernel number, 100-kernel fresh weight and plant height was low, despite high trait heritabilities, and pointed at high levels of epistasis. Relative chlorophyll contents (SPAD, only in Mexico) of the ear leaf and the second leaf from the tassel were controlled by a constitutive and a stress-adaptive QTL (chromosomes 2 and 10), the latter also affecting whole-plant senescence.

The results showed that drought tolerance mechanisms were largely masked by plant vigour, because of the distinct morphology and yield potential of the parental lines. The poor adaptation of the plants to the Mexican environments resulted in a larger number of QTLs than in Zimbabwe and in significant QEI when combining data across locations and water regimes, even though the QTLs were stable within each environment. Therefore, care must be taken when choosing plant material for genetic studies. QTLs involved in plant adaptation are very important in breeding for broad target environments, and methods to detect epistasis are needed to better understand drought tolerance mechanisms.

Keywords: Drought tolerance, epistasis, plant vigour, QTL-by-environment interactions, quantitative trait loci, *Zea mays*

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