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Water Deficit and Drought Tolerance Mechanisms in Crops

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The evolution of crops since their domestication has been driven by the selection of desired traits recognized at the phenotypic level. Nevertheless, direct selection for grain yield under water-stressed conditions has been hampered by low heritability, polygenic control, epistasis, significant genotypeby- environment (G _ E) interaction and quantitative trait loci (QTLs)-by-environment (QTL _ E) interaction (Piepho, 2000). The complexity of drought tolerance mechanisms explains the slow progress in yield improvement in droughtprone environments. In recent years, crop physiology and genomics have led to new insights in drought tolerance providing breeders with new knowledge and tools for plant improvement (Tuberosa and Salvi, 2006).

Physiological traits related to drought tolerance: Growth in biomass depends on the carbon balance between photosynthesis and respiration. Expansive growth, defined as an increase in organ volume through water entry into growing cells, depends on the interplay of cell wall extensibility, gradients of water potential, and hydraulic conductance on the water pathway to cells . Carbon gain and expansive growth have essentially opposite phases. Leaf photosynthesis and whole-plant carbon balance follow changes in light intensity and plant transpiration, with peak values close to midday .

Morphological changes during drought stress tolerances: Drought resistance mechanisms in plants are composed of four categories: recovery, avoidance, tolerance and drought escape. Water stress avoidance is the sustaining of important physiological processes such as stomatal regulation, when exposed to mild drought. Drought tolerance is the ability of flora to endure severe dehydration via osmotic adjustment and osmo-protectants . Plants are evolved to regulate growth period to avoid moisture stress; termed as drought escape. Drought recovery is the ability of plants to continue growth after drought injury. In cotton, biochemical, physiological and molecular strategies against drought stress are reviewed in the proceeding sections.

Advanced Breeding technology for Drought stress tolerance: Identification of drought-resistance QTLs is essential to provide valuable targets in crop breeding. Li et al. identified four genetic regions containing SNPs significantly associated with several different traits in chickpea under drought by GWAS. This result indicated pleiotropic effects of drought-resistance associated QTLs. Gudys *et al*. identify 11 candidate QTLs of physiological and biochemical traits associated with drought-tolerance in Barley on a high-density function map. They further prioritize 143 candidate genes by their potential involvements in certain biological processes based on Gene Ontology annotation.

Conclusions and future prospectus: Breeding for drought must be conducted with adequate concern for the selection environment. Adequate care and appropriate consideration must be given to the genotype X environmental interaction during selection of parents and segregants at each filial generation.

Marker assisted breeding approach is another better method for developing drought resistance crops not only because of its less time consuming but also labor and cost effective. Molecular mapping and analysis of QTL have been carried out in various traits related to drought and have resulted in greater magnitude of better understanding drought traits. However, there is a bigger challenge of using this knowledge to manipulate genes in an effective way to improve specific traits in a crop. These challenges include precise QTL identification, genetic and environmental interaction, various numbers of genes regulating yields and invalid use of mapping of QTL. Most of the transgenic plants developed are not tested under field conditions therefore; their performance under the field conditions is yet a question mark. The use of conditional promoters driving gene expression at specific developmental stages, in specific tissues/organs and/or in response to specific environmental cues, circumvents this problem and will make possible the generation of transgenic crops able to grow under various abiotic stresses with minimal yield losses.

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