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Untangling the Terminal Drought Tolerance in Groundnut

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SUMMARY

Groundnut, despite being an important legume crop both in subsistence and commercial agriculture in arid and semi-arid regions of the world is largely affected by terminal drought stress. Frequent occurrence of drought is one of the limiting factors that adversely affecting groundnut productivity, especially in rainfed areas. Notably, till now, the information on the effect of terminal drought on yield, yield components and physiological attributes in predominant elite cultivars has not been investigated thoroughly. To reduce yield losses from drought stress, identification and development of tolerant peanut genotypes to water deficit at the end-of-the season-stage is an important breeding goal to assuage drought effects on peanut yield.

INTRODUCTION

Groundnut, an important nutritious legume is a dry fruit for protein enrichment to acquire the so-called nutritional security towards marginal land farmers additionally, valued both for edible oil and confectionery purposes as well as culinary preparations as well as rich source of edible oil (48-50%), high quality protein (25-28%), crude fibre (2.8%), carbohydrates (13.3%) and all vitamins as well as minerals. Moreover, the groundnut haulms deliver superior quality enrich with protein hay as animal feed. It is increasing in terms of acreage in hot arid climatic regions. Researchers are also focusing on varietal developmental programs based on arid climatic regions. But, the changing climatic conditions and irregularities in rainfall pattern observed in recent time indicating a serious threat to the existing variety chain or cultivar chain system and thus posing an implausible challenge in front of the groundnut breeders.

Many researchers concluded that this low productivity may be attributed to cultivation of crop predominantly under marginal and submarginal lands (mainly in rainfed conditions), biotic and abiotic stresses and many socio-economic factors (Hampannavar and Khan 2019). The irregular rainfall in the rainfed conditions (having major cultivation of groundnut) has been denoted as a most significant climatic factor affecting groundnut production in the arid and semi-arid regions among the numerous abiotic stresses. Many researchers reported up to 70% yield losses in groundnut due to terminal drought stress.

Groundnut yield in rain-fed areas has been limited by the drought stress. Pod yield and other growth parameters have been severely affected (Pimratch et al. 2008;Nautiyal et al. 2002). Yield losses have been estimated up to 56-85% depending on crop growth stage when it was exposed to drought (Reddy et al. 2003), drought intensity and drought duration. Moreover, Girdthai et al. (2010) indicated the pod filling and seed formation stage as the most critical stage in case of drought occurrence by reporting the largest reduction in peanut pod yield when water deficient conditions formulate at these stages. Even in irrigated areas, groundnut is frequently exposed to drought because water supply is not sufficient. Frequent occurrence of drought is one of the limiting factors that adversely affecting groundnut productivity, especially in rainfed areas. Water deficits in the pegging decreased pod and seed growth rates by approximately 30% and decreased weight per seed from 563 to 428 mg. (Sexton et al.1997).

The importance of terminal drought stress was explained by Jogloy et al. 2008 by quoting that peanut plants may experience water stress during pegging and pod development and then may have adequate amount of water. This would result in a drastic reduction of crop yield, and the magnitude of reduction would depend on peanut cultivars. Notably, till now, the information on the effect of terminal drought on yield, yield components and physiological attributes in predominant elite cultivars has not been investigated thoroughly. To reduce yield losses from drought stress, identification and development of tolerant peanut genotypes to water deficit at the end-of-the season-stage is an important breeding goal to assuage drought effects on peanut yield.

Drought stress resistance mechanisms

Drought Escape: Ability of a plant to complete its life cycle before it is exposed to stress. (Early vigor, early flowering and maturity).

Drought Avoidance: Ability of a plant to maintain relatively higher tissue water potential in water stressed environments. (Smaller leaf area, deeper and larger root systems etc.)

Drought Tolerance: Inherent ability of the plant cells to participate in metabolism in spite of water deficit in the leaf tissues. (Cell elasticity, osmotic adjustment, accumulation of solutes, osmoregulants and membrane stability)

Breeding for Terminal Drought Tolerance

Exploration for DRTs:

The vast potential of wild species, reservoir of new alleles remains under-utilized. Hence utilization via interspecific crosses provides new sources of terminal drought tolerance in groundnut.

Phenomics and field selection:

Genetic variability is the basis of plant breeding. Therefore, it is important to screen diverse groundnut genotypes for stable grain yield and associated characteristics under terminal drought stress. Notably, a large reduction in pod yield, and the reduction percentage also varies among peanut cultivars (Nageswara Rao et al. 1998). The varieties should be able to provide higher yield under drought. Genetic variability for drought resistance has been reported in groundnut (Songsri et al. 2009). However, breeding for drought resistance based on pod yield is lacking behind due to significant genotype and environment interactions. Concurrently, physiological surrogate traits bearing proximity to drought endurance in crops likewise relative water content, canopy temperature, specific leaf area, and SPAD chlorophyll meter reading can also be utilized (Nagaveni and Khan 2019).

Artificial screening and selection (viz., PEG):

Tailoring groundnut varieties with tolerance to drought and efficient in water use offers the best long term and cost-effective solution to encounter the uncertainty of monsoon and shrinking availability of irrigation water in country. Many researchers (Shankar et al. 2019;Mahanteshet al.2018) used putative PEG (polyethylene glycol) as artificial drought inducer and screened existing genotypes at seedling stages. this facilitates the fastening of breeding process for tolerance. Selection of tolerant genotypes will help to further transfer this tolerance in high yielding varieties by various breeding methods. In addition to field experiments, the germination of seeds under artificially generated drought conditions in laboratory offers effective confirmation of field screening. This additional support of field screening validates drought tolerant genotypes.This additional support of field screening validates drought tolerant genotypes.

Marker assisted breeding:

Development of linkage maps of groundnut during the last decade was followed by identification of markers and quantitative trait loci for the target traits.

Genomic assisted breeding:

For the identification of candidate QTLs for drought tolerance, a comprehensive and refined genetic map containing 191 SSR loci based on a single mapping population (TAG 24 × ICGV 86031), segregating for drought and surrogate traits was developed (Ravi et al 2010). Availability of draft genome sequence for diploid (AA and BB) and tetraploid, AABB genome species of Arachis in coming years is expected to bring low-cost genotyping to the groundnut community that will facilitate use of modern genetics and breeding approaches such as genome-wide association studies for trait mapping and genomic selection for crop improvement.

Transcriptomics:

To identify the drought-responsive genes preferentially expressed under drought stress in different peanut genotypes.RNA-sequencing (RNA-Seq), a technique for genome-wide gene expression analysis, provides a powerful alternative to facilitate the development of drought-tolerant genotypes(Wang et al. 2021). Recently, candidate genes and expression profiles in many crops, including wheat, corn, soybean, and peanut, evaluating plant response to environmental stress conditions were determined with RNA-Seq technology (Zhao et al.2018; Long et al. 2019).

CONCLUSIONS

In the era of altering rainfall pattern and distribution and owing to its long duration cropping nature groundnut is very sensitive towards terminal drought stress, a frequent occurring phenomenon of hot arid climatic zones impacting the crop productivity at drastic levels. Thus, acquiring drought tolerance in putative cultivars is continuous research topic amidst groundnut breeders with simultaneous indulging of the new breeding initiatives like allele mining through genomic assisted breeding, gene mining through transcriptomics and pathway mining through proteomics. It indicated the urgent need of the time to combine conventional approaches followed by screening procedure including visual and modern phenomics facilities can be used in development of tolerant groundnut in the near future.

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