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Derleme Makalesi

Abiotic Stress Factors & Diseases of Durum Wheat (*Triticum turgidum* ssp. *durum*)

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Abstract

When considered on global scale, durum wheat is considered a minor wheat crop but is an important cereal in semiarid parts of Middle East, North Africa, South Europe and North America. Durum wheat is well adapted to high temperatures and semiarid conditions but under Mediterranean conditions, water deficiency and high temperature during reproduction period limit durum production severely. Apart from abiotic factors, Fusarium head blight, stripe rust, leaf rust and stem rust are major diseases resulting with serious yield losses in durum wheat. Abiotic stress factors, especially drought and high temperature, and major diseases of durum wheat effective worldwide, are the subject of this review.

Keywords: Durum wheat, *Triticum turgidum* ssp. *durum*, drought, high temperature, diseases

INTRODUCTION

Globally, durum wheat is still considered a minor wheat crop and research efforts on durum is mostly conducted in relation with bread wheat (Beres et al., 2020). Durum is an important cereal in semiarid parts of Middle East, North Africa and South Europe in Mediterranean basin (Hammami & Sissons, 2020). Major consumption areas of durum are pasta, bulgur, couscous and bread production (De Vita & Taranto, 2019). The genetic improvement of durum wheat requires identification of stable QTLs (quantitative trait loci) and linked markers. This helps understand the genetic basis of important traits more and identify a method for selection during breeding. Meta-QTL analysis approach is useful to be used in the marker-assisted selection for this aim (Soriano et al., 2021). Association mapping allows to choose a more accurate characterization of QTLs in genetic background (Cane et al., 2014). High-density genetic linkage maps of durum are particularly useful in detection of quantitative and qualitative QTLs for important agronomical traits and to identify candidate genes (Colasuonno et al., 2014). Selection of single durum wheat plants is a step at early generations during breeding but populations are highly heterogeneous. Instead, leaf weight and spike partitioning of single plants at anthesis have significant positive relation to crop yield (Pedro et al., 2012).

Effects of high temperature and drouht on durum wheat

Genomic applications of durum have potential for exploitation of genetic resources and understanding important complex traits such as tolerance to abiotic and biotic stress factors because durum wheat is generally cropped in medium-low precipitation areas in the world (Maccaferri et al., 2014). Durum wheat is well adapted to high temperatures and semiarid conditions compared to bread wheat but climate change is threatening durum wheat production (De Vita & Taranto, 2019). It is generally assumed that durum has higher tolerance to stress compared to bread wheat (Marti & Slafer, 2014). Durum has great economic importance in developing countries in Mediterranean region but decreases in its production is expected in future due to climate change (Dettori et al., 2011). Mediterranean basin, especially North Africa is highly vulnerable to climate change (Chourghal et al., 2016). Crops get affected from climate change due to inter-relationship of crop development, growth, atmospheric CO2 levels, climatic conditions, reduction in water resources and increase in temperature (Ventrella et al., 2012). Under Mediterranean conditions, water deficiency and high temperature during reproduction period limit cereal crop production severely (Liu et al., 2019). Water deficit is the major limiting factor in Mediterranean basin and durum yield is greatly reduced by drought in this zone. Grain filling rate and duration and distribution of assimilates in stems have important effects under stress conditions on yield performance of durum wheat (El Fakhri et al., 2012).

Fig. 1. New botanical varieties and forms of durum wheat (*T. durum* Desf.): Upper right to left 1) *T. durum* var. *falcaticaerulescens,* 2) *T. durum* var. *falcatiprovinciale,* 3) *T. durum* var. f*alcataffine*, 4) *T. durum* var. *falcaterythromelan*. Lower right to left 1) T. durum var. *muticerythromelan,* 2) T. durum var. *muticoleucomelan,* 3) *T. durum* var. *caumelanopus,* 4) *T. durum* var. *Falcativalencia* (Lyapunova, 2017).

Drought and/or heat stress during growth affect the processing quality of durum. In a study of Li et al., (2013), lactic acid retention capacity and mixograph peak time increased under drought and decreased under heat stress. Heat and drought stress sharply reduced grain yield but increased yellowness (Li et al., 2013). 154 durum landraces and 18 modern cultivars from 20 Mediterranean countries were used in field experiments under rainfed conditions during three years in Spain conducted by Nazco et al., (2012). Environmental conditions effected grain protein content, grain yield and grain flour yellowness most. Landraces from the eastern Mediterranean countries recieved highest mean quality index (protein content, gluten strength, yellow color index and thousand kernel weight) and individual quality trait variability, but grains were relatively small. Landraces of western Mediterranean countries had heavier grains and higher grain filling rates. Modern cultivars, as a group, were the most productive and showed high quality index, but they had the lowest grain protein content and phenotypic variability (Nazco et al., 2012).

Diseases of durum wheat

Fungi from durum wheat grown soil was isolated from soil and plant samples and classified by PCR amplification and sequencing in the study of Vujanovic et al., (2012). Total

46 fungal species were identified. Most of them were from *Ascomycota* phyla. A few were from *Zygomycota* and *Basidiomycota* phyla. *Penicillium*, *Fusarium* and *Geomyces* spp. were abundant throughout growth stages and plant organs. Seventeen species were found potential pathogens of durum where *Fusarium* are the most abundant. Other pathogenic taxa were *Pyrenophora*, *Alternaria*, *Nigrospora*, *Microdochium*, *Bipolaris*, *Phaeosphaeria*, *Arthrinium* and *Cladosporium* taxa (Vujanovic et al., 2012). Fusarium head blight (*Fusarium graminearum*) is a major diseases of durum wheat reducing yield and quality. Mycotoxins also contaminate grains (Gorczyca et al., 2018). Deoxynivalenol is the most important mycotoxin produced by *Fusarium* moulds (Bensassi et al., 2010). There is an unfavorable correlation with plant height and heading date for durum wheat on the effect of Fusarium head blight. Selection of multiple traits is hard for breeders due to associations of different characters (Moreno-Amores et al., 2020). Breeding for resistance to *Fusarium* in durum is prevented by the lack of resistance resources. Information on resistance QTL for Fusarium head blight in durum is also limited (Buerstmayr et al., 2012). Improvement for *Fusarium* resistance is hard particularly due to the limited genetic variation in the durum wheat species (Buerstmayr et al., 2013). Fusarium head blight threatens durum production in many growth regions (Zhang et al., 2014). Genomic selection response is higher than phenotypic selection response to obtain *Fusarium* resistance (Steiner et al., 2019). Stripe rust (*Puccinia striiformis* f. *tritici* Eriks.), leaf rust (*Puccinia triticina* Eriks.), and stem rust (*Puccinia graminis* f. sp. tritici) are major diseases making serious yield losses in durum wheat (Singh et al., 2013). Identifying new genes is essential for resistance against the diseases (Xu et al., 2013). Stem rust was historically a destructive diseases of durum wheat worldwide (Haile et al., 2012). A stem rust race named TTKSK (Ug99) was identified in 1999 in Uganda. It is still virulent on many resistance genes and is rapidly spreading to other countries (Simons et al., 2011). More than 50 resistance loci for stem rust was identified in wheat but just a few are effective for Ug99 race (Letta et al., 2013).

Fig. 2. Uredinia of leaf rust on flag leaves of wheat (Photo: Mark Hughes, USDA) (Kolmer, 2013).

Resistance breeding to stripe rust is a major objective for durum wheat (Liu et al., 2017). Leaf rust, is an important diseases of common wheat and durum wheat worldwide (Chhetri et al., 2017). Resistance to leaf rust is one of a main target for durum wheat and association mapping on germplasms is used as an approach to discover and validate major genes and QTLs (Maccaferri et al., 2010).

CONCLUSIONS

Durum wheat is well adapted to high temperatures and semiarid conditions compared to bread wheat but climate change is threatening durum wheat production. Especially especially North Africa durum production is highly vulnerable. Apart from abiotic factors, Fusarium head blight, stripe rust, leaf rust and stem rust are major diseases resulting with serious yield losses in durum wheat. Innovative solutions to these diseases are required for durum wheat.

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