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THE ABIOTIC STRESS RESPONSE AND ADAPTATION OF TRITICALE

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Triticale is a crop species resulting from a plant breeder's cross between wheat (*Triticum*) and rye (*Secale*). Abiotic Stress and TriticaleSince the initiation of triticale as a commercial crop in the 1960s, breeders expected it tobe more resilient than wheat, considering the relative hardiness of its rye parent. It seemsthat the opinions on the hardiness of rye in terms of coping with soil and atmosphericstresses were derived from ample historical experience of farmers and some research. Most work on triticale adaptation to abiotic stress attempted to obtain reliable data on thecomparative stress resistance of triticale and its parents. Abiotic stress research withtriticale developed from the 1970s into the early 2000s, after which it seems to dwindle. Triticale is mainly grown as feed grain and biomass production [1].

Drought. The physiology of drought stress and the characterization and phenotyping of drought resistance have greatly advanced in recent years (e.g. Araus et al. 2002; Blum 2011; Reynolds et al. 2012). The primary reasons for yield reduction under various profiles of drought stress are now reasonably understood. The genetic and physiological background of plant drought stress and adaptation has been well studied to the extent that cereal breeding can effectively improve plant production in water-limited environments by addressing its stress physiology. The essence of this knowledge must be presented here in order to discuss well the case of triticale.Very briefly, productivity-related drought resistance in cereal crops is quantitatively associated with sustained turgor, sustained stomatal conductance and sustained assimilation as soil moisture is depleted. Turgor is sustained by effective soil moisture capture and/or by leaf osmotic adjustment. Complete stomatal regulation of transpiration can be enhanced by the total reduction of cuticular transpiration mainly through sufficient deposition of epicuticular wax which also increases canopy albedo. The combined result of any or all of the above is defined as effective use of water (EUW). Resistance of the reproductive functions under low plant water status is crucial when stress occurs at flowering. Such resistance can be controlled by turgor maintenance, carbon supply, hormonal regulation or certain constitutive traits of the gametophyte.

Waterlogging. Setter and Waters (2003) reviewed the possibility of improving waterlogging resistance in certain cereals and provided some views on the subject in triticale. They felt that there was a perception among farmers that oats and triticale were more waterlogging resistant than wheat and barley. A study of germination survival under 4 days of waterlogging indicated that mean germination survival was greater in oats and triticale than in wheat and barley. However, the data show that the range of resistance in 3 triticale varieties was similar to the range across 11 Australian wheat cultivars studied. In another study under waterlogged field conditions oats and triticale expressed somewhat greater root parenchyma formation than wheat and barley. When one triticale was compared with two wheat cultivars under hypoxia stress in nutrient solution triticale performed better than wheat in root growth and better than one of the wheat's in shoot dry matter. One triticale was compared with two wheat cultivars under stagnant nutrient culture and waterlogged soil. Triticale performed better than wheat under these conditions with respect to shoot weight, root weight and parenchyma development in roots. It can therefore be concluded that triticale is generally more waterlogging and hypoxia resistant than wheat, most likely due to better root growth and function [2].

Cold. Rye is more cold tolerant than wheat. The rye genome component of triticale naturally allows expecting greater cold tolerance of triticale over that of wheat. Frost damage at heading and flowering is a serious problem in certain agro-ecological zones of wheat, where one night of freezing temperatures can reduce yield appreciably.

Salinity. According to data collected by the USDA Salinity lab, the salinity tolerance of triticale is basically better than that of wheat and might even approach that of barley.

*Mineral Toxicity.*Acid soil associated with aluminum toxicity is a widespread problem in cereals. An extensive field study of complete and substituted triticales over diverse soils in Spain (Royo et al. 1993) found that the main factor for yield variation was soil pH. Complete triticales outyielded substituted triticales in the majority of sites.

In summary interest in the abiotic stress response and adaptation of triticale understandably developed with the expansion of triticale breeding and acceptance during the last quarter of the 20th century. While important issues still remain unresolved, research on stress response of triticale tended to decline in the 21st century. The development of crop genomics research in recent years touched triticale also (e.g. Tyrka et al. 2011) and in the future it will hopefully impact triticale breeding for abiotic stress resistance as well as its grain and baking quality. Presently, triticale stands as a crop of high biomass and yield potential which generally surpass that of wheat. Its high potential might stem from high rates of carbon assimilation linked to stomata physiology and probably low respiration rate. The work cited in this review indicates that triticale retain good to excellent adaptation to limited water supply and problem soils which involve salinity, low pH, and defined mineral toxicities and deficiencies. This resilience of triticale was expressed even when just one triticale cultivar was compared with numerous representatives of wheat or other cereals. In most (but not all) cases this resilience could be traced to its rye parent. Despite the understandable expectations, freezing tolerance of triticale was not found to be up to the level of the best winter wheat. The expected effect of the rye genome towards the freezing tolerance of triticale seems to be inhibited by unknown factors on the wheat parent genome [3].

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