Physiological Studies on the Response of Wheat to Short-term Heat Stress during Reproductive Development

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School of Agriculture, Food and Wine
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THE UNIVERSITY OF ADELAIDE
DEDICATION

I would like to dedicate my thesis

To our

Beloved late Parents

&

Beloved late daughter

Tahira Morshed TALUKDER
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ABSTRACT

In Mediterranean environments, cereal crops are often exposed to short periods of elevated temperatures in spring when crops are approaching flowering and grain filling. Most studies on heat stress have focused on crop responses to extended periods of high temperature under controlled environment (CE) conditions possibly due to difficulties in applying heat stress in the field. It is possible wheat may respond quite differently to heat stress imposed under field and CE conditions. Therefore, experiments were designed to develop a methodology to apply heat treatments in the field. Studies were also undertaken to compare the response of wheat genotypes to a single-day heat stress event in the field and CE conditions.

Wheat genotypes were exposed to heat stress for a single-day at two different stages, near flowering or green anther stage (H1), and early grain set or 7-10 days after anthesis (DAA) (H2) in 2009 and 2010. Heat treatment was applied in the field in a portable purpose-built heat chamber in which the temperature was steadily increased to a maximum of 35°C, which was maintained for 3 hours before being allowed to steadily decrease to the ambient temperature, like a typical natural spring heat event. Similar to the field studies, wheat genotypes were also exposed to a single-day heat event (35°C maximum) in the CE study. This single-day heat stress event caused a significant reduction in flag leaf chlorophyll content, peduncle water soluble carbohydrate (WSC), grain yield and yield components in both years. There was no significant difference between H1 and H2 for most of the measurements with a few exceptions.

The maximum WSC content was reduced by heat stress in all wheat genotypes. Heat stress (average of H1 and H2) reduced peduncle WSC content by 26% and mobilized WSC content by 15% across all studies. Mobilization of peduncle WSC content was also significantly
reduced by the heat stress treatments. Genotypes with high WSC such as CM9-6Y, CM9-4Y showed lower sensitivity to heat stress than Janz, which had the lowest peduncle WSC content. Heat stress accelerated the rate of loss of flag leaf chlorophyll content. A higher rate of senescence in 2009, which was warmer and drier than 2010, was associated with greater yield loss. Reduction in grain yield among the genotypes was negatively correlated (r = -0.79; p<0.001) with the rate of flag leaf senescence. Heat stress reduced post-heading duration and grain yield across genotypes and heat stress treatments was strongly correlated (r = 0.80; p<0.001 in 2009 and r = 0.82; p<0.001 in 2010) with post-heading duration. Standardized partial regression coefficient (b) showed that the contribution of grain number (b = 0.786) to the grain yield was higher than IGM (b = 0.435) in 2009. In contrast, IGM (b = 0.665) appeared to be a stronger contributor to the grain yield than grain number (b = 0.443) in 2010. Relative to the unheated control, heat stress caused only a small reduction in grain set in the florets a and b (5% each) but there was a significant (p<0.001) reduction in grain set in florets c (16%), d (31%) and e (68%). However, heat stress also caused a sharp decline in grain number in positions a and b in the distal spikelets of Janz and Gladius but not in other wheat genotypes. Averaged over the growing conditions, seasons and across florets positions, the reduction in grain set due to heat stress was greater in Janz (35%) than CM9-4Y (14%), followed by CM9-6Y (18%), Krichauff (18%) and Excalibur (26%). Similarly, when averaged over years and growing conditions and florets positions, the reduction in IGM by heat stress was higher in Janz (33%) than CM9-6Y (15%), followed by Krichauff (17%) and CM9-4Y (20%). Grain yield loss of different wheat genotypes was strongly correlated (r = 0.91; p<0.001) between the field and CE. The results of these studies showed that under field and CE conditions, Janz was consistently the most sensitive genotype to heat stress. In contrast, CM9-6Y, CM9-4Y and Krichauff appeared to be most tolerant to heat stress. Averaged over the two growing seasons and heat stress treatments, the reduction in grain
yield was greater in Janz (25%) than in CM9-6Y and CM9-4Y (13% each), followed by Krichauff (16%) and Excalibur (18%).

It could be argued that selection of early headed wheat genotypes with slower rate of leaf senescence, longer post-heading duration, higher stem WSC reserves, and greater mobilization of WSC could be used to buffer grain growth and development under heat stress conditions, which are a common occurrence in the Australian wheat belt.
DECLARATION

I certify that this work contains no material which has been accepted for the award of any other degree or diploma in my name, in any university or other tertiary institution and, to the best of my knowledge and belief, contains no material previously published or written by another person, except where due reference has been made in the text. In addition, I certify that no part of this work will, in the future, be used in a submission in my name, for any other degree or diploma in any university or other tertiary institution without the prior approval of the University of Adelaide and where applicable, any partner institution responsible for the joint-award of this degree.

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...... Date.................

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