Effects of Zinc Nutrition and High Temperature on the Growth, Yield and Grain Quality of Wheat (*Triticum aestivum* L.)

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ABSTRACT

Wheat production is the largest enterprise within the Australian grain industry, with an annual gross value of production of approximately $4 billion. However high temperature stress (>35ºC) and zinc (Zn) deficiency in soils are a frequent occurrence across the Australian wheat belt and represent two of the most important environmental limitations to wheat production and grain quality. The work presented here has shown for the first time that Zn nutrition can provide wheat plants with a level of tolerance to high temperature stress.

Field trials, along with controlled environment studies, showed that supplementary Zn nutrition improved photosynthetic activity during a high temperature event, by stabilising chlorophyll initial fluorescence, Fo. Since increases in Fo under heat stress are associated with an increase in lipid fluidity of the thylakoid membranes at high temperature, the results suggested that adequate Zn fertilisation could preserve membrane integrity during heat stress. Electron microscopy confirmed this hypothesis, and showed that adequate Zn nutrition could maintain the integrity of a number of cellular membranes during high temperature, including the tonoplast, chloroplast envelope and the thylakoid membranes.

Measurements of canopy temperature depression showed an improvement in the evaporative cooling of the canopy with supplementary Zn nutrition in the Zn inefficient varieties, suggesting better soil water extraction under warm conditions. Supplementary Zn nutrition also increased the kernel weight of plants grown under warm conditions in the field, however this was unrelated to the improvement in photosynthetic activity. Nevertheless, results from both controlled environment and field experiments demonstrated that the detrimental effects of low Zn availability and high temperature on the yield of Zn inefficient or thermosensitive wheat varieties will be most damaging when these stresses occur in combination.

Analysis of protein composition showed that supplementary Zn fertilisation increased

the glutenin:gliadin ratio in the grain. This suggests that Zn fertilisation may improve the bread-making quality of wheat under conditions of Zn deficiency. The results also showed a negative association between grain Zn concentration and the number of days over 35ºC during grain filling, which suggests that the negative effects of high temperature stress on grain protein composition will be compounded when plants are grown on soils of low Zn availability.

This thesis represents a valuable contribution to the understanding of the relationships between micronutrient supply and environmental stress. Further studies should be undertaken to establish whether the protective effect of Zn on the photosynthetic apparatus will be maintained under consecutive heat stress events, to determine the ways in which Zn ions stabilise and protect bio-membranes under heat stress and to confirm the positive effects of Zn on grain protein composition and baking quality.

DECLARATION

This thesis contains no material which has been accepted for the award of any other degree or diploma in any university or other tertiary institution and, to the best of my knowledge and belief, contains no material previously published or written by any other person, except where due reference has been made in the text.

I give consent to this copy of my thesis, when deposited in the University Library, being available for loan and photocopying.

……..Date……

Alison W Graham

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