PHYSIOLOGICAL STUDIES ON STERILITY INDUCED IN WHEAT BY HEAT AND WATER DEFICIT

by

HARGURDEEP SINGH SAINI

B.Sc.(Hons.), M.Sc.(Hons.)

Department of Plant Physiology

Waite Agricultural Research Institute

The University of Adelaide

South Australia

Thesis submitted for the Degree of

Doctor of Philosophy

1982

TABLE OF CONTENTS

3. RESULTS AND DISCUSSION

APPENDIX

Research papers based on the results of the present investigation, published or accepted for publication before the completion of this thesis.

1. SAINI, H.S. and ASPINALL, D. (1981). Effect of water deficit on sporogenesis in wheat (*Triticum aestivum L.)* *Ann. Bot.* 48: 623-633.

2. SAINI, H.S. and ASPINALL, D. (1982). Abnormal sporogenesis in wheat (*Triticum aestivum* L.) induced by short periods of high temperature. *Ann. Bot.* 49: 835-846.

3. SAINI, H.S. and ASPINALL, D. (1982). Sterility in wheat (*Triticum aestivum* L.) induced by water deficit or high temperature : Possible mediation by abscisic acid. *Aust. J. Plant Physiol.* 9: in press.

SUMMARY

1. Wheat plants were subjected to water deficit by withholding water or to heat stress by exposure to 30°C for 3 days during various stages of development between the onset of meiosis and completion of anthesis. Both treatments when applied during meiosis in the pollen mother cells and tetrad break up (sensitive stage) caused significant reductions in grain set and yield.

2. High temperatures of 30°C for 1 day or 30°C day/20°C night for 3 days during the sensitive stage also caused significant reduction in grain set.

3. Decrease in grain set in response to these stresses was followed by a compensatory increase in the weight of the surviving grains, this increase being greater when the grain set was affected by water deficit than by heat.

4. Water stress during the sensitive stage caused a substantial drop in the relative water content and water potential of the leaf but did not affect spike water potential. Heat stress during the same period had no effect on any of these attributes. The results suggest that water stress affected grain set without causing desiccation of the spike tissue and that the effects of heat stress were not because of water loss from the plant as a result of elevated temperature.

5. Both water- and heat-stress caused reduction in grain set by inducing male sterility. However, only heat-stress affected female fertility.

6. Heat-stress induced structural abnormalities in the embryo sacs and nucellus tissue and adversely affected the growth of pollen tubes when heat-stressed pistils were pollinated with fertile pollen. It is proposed that the effects of heat on pollen tube growth were due either to the disruption of nutrition of pollen tubes by the stigma/style or to defective attraction signals from abnormal embryo sacs.

7. In about half of the abortive anthers on water-stressed plants, the pollen grains lost contact with the tapetum at about the time of first pollen grain mitosis and showed suppressed intine development and starch accumulation. These abnormalities were associated with the degeneration of the filament and vascular bundle. The remainder of the abnormal anthers showed similar disruption of pollen development but had apparently normal filaments and vascular bundles.

8. About half of the heat-affected anthers showed degeneration of microspores during meiosis coupled with premature tapetal degeneration. The rest of the anthers aborted in a similar way to those affected by water stress, but did not show abnormalities in the filament tissue. It is suggested that there may be qualitative differences between the effects of water stress and heat on sporogenesis in wheat.

9. Abnormal anthers induced by water- or heat-stress were morphologically similar. These anthers were relatively small, frequently shrivelled and generally failed to extrude or dehisce at anthesis. They contained pollen grains that did not stain with 2,3,5-triphenyl tetrazolium chloride, indicating a lack of viability. Pollen viability was reduced by stress also in anthers that looked apparently normal.

10 Water stress resulted in an accumulation of abscisic acid in the spikelets. Application of abscisic acid solution at the stress-sensitive stage of development augmented the endogenous concentration of the hormone, reduced grain set and induced male-sterility, but not female sterility. Application of the hormone after meiosis had no such effects. Although the abnormal anthers and pollen grains on abscisic acid-treated plants appeared similar to those affected by water stress, their pattern of development was different. Approximately 75% of the anthers that aborted in response to the application of abscisic acid showed the beginning of abnormal microspore and tapetal development at meiosis. Water-stress affected anthers aborted after the first pollen grain mitosis and, at least half had degenerate filaments. It is therefore, suggested that despite the apparent similarities in the responses to water stress and applied abscisic acid, the two may

affect pollen fertility through different mechanisms.

11. Compared with untreated plants, heat-stress (30-40°C for 1-3 days) did not cause an increase in the endogenous concentration of abscisic acid in spikelets or flag leaf, indicating that the mechanism of induction of sterility by heat is unlikely to involve abscisic acid.

12. Spraying plants with ethephon or exposing them to ethylene-supplemented air during the sensitive stage caused a reduction in grain set via an induction of male sterility. Application of either of the treatments after meiosis had no effect on grain set. Anthers and pollen grains affected by the application of ethephon or ethylene had similar structure to those sterilized by water stress or heat. In the light of the published information on the increase in ethylene emanation from the stressed tissues, it is postulated that ethylene may be involved in the mechanism of induction of sterility by stress.