SOME EFFECTS OF WATER STRESS AND ENVIRONMENT ON SOYBEAN PLANTS

A thesis presented in partial fulfilment of
the requirements for the degree of
Doctor of Philosophy in Botany
at
Massey University

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1970

ABSTRACT

Although a great deal of research has been carried out on the effects of water stress on plant processes, the influence of environmental conditions on plant response to water stress has received comparatively little attention. In this study the rates of CO_2 exchange and transpiration and the leaf water status of whole soybean plants (*Glycine max* (L.) Merr. cv. Merit) were measured under contrasting sets of environmental conditions when

(a) the plants were maintained under conditions of adequate soil water supply.

(b) water stress was imposed by withholding water and,

(c) when water stress was imposed and then relieved by rewatering.

Light intensity and quality, atmospheric CO_2 concentration, wind speed and daylength were all constant; the between-treatment variables were air temperature and vapour pressure deficit (VPD). Plants were grown under one of four environmental treatments in a growth cabinet and the experiments carried out under very similar conditions in a plant chamber with facilities for measuring CO_2 exchange and transpiration. Details of this equipment are given.

Under conditions of adequate soil water supply rates of photosynthesis were lower under low VPD than under high VPD conditions at the same temperature. The effect was particularly marked at low temperature (22.5°C). Between-treatment differences in photosynthetic rate appeared to be mainly attributable to differences in the magnitude of the mesophyll resistance to CO_2 transfer. Transpiration rates were largely determined by the VPD, plants under high VPD treatments having the higher rates. At low VPD temperature had little effect on the rate of transpiration, but at high VPD plants under low temperature had lower rates of transpiration than plants under high temperature (27.5°C). Possible mechanisms whereby low temperatures may reduce transpiration under conditions of high VPD are discussed.

When water stress was imposed the rates of photosynthesis and transpiration declined in parallel under all treatments at soil moisture tensions in excess of 0.2 atm. This suggested that both plant processes were subject to a common controlling mechanism, probably stomatal diffusion resistance. At soil moisture tensions below 0.2 atm. the rates of photosynthesis and transpiration were independent of the soil moisture status. Between 0.2 and 0.4 atm. tension they appeared to be determined by plant, soil and atmospheric factors. The relative rates of photosynthesis and transpiration were reduced to a

greater extent at any tension between 0.2 and 0.4 atm. under high VPD than under low VPD conditions. Above 0.4 atm. soil moisture tension the rates of photosynthesis and transpiration became independent of the atmospheric conditions and it is suggested that transpiration was limited chiefly by the rate of movement of water into the root zone from the surrounding soil. Photosynthesis may have been limited by direct effects of dehydration on the biochemical components of the process at these severe stress levels. It was thus possible to distinguish three stages in the development of water stress, the significance and possible general application of which are discussed.

Under high temperature/high VPD conditions the rates of photosynthesis and transpiration recovered simultaneously and to a very similar extent when stress was relieved by rewatering, the degree of recovery being inversely proportional to the soil moisture tension at the time of rewatering. Possible causes of the failure of the rates of photosynthesis and transpiration to recover to their original prestressed values are discussed.

These results are discussed in relation to the findings of other workers, and suggestions for further research in this field made.

ACKNOWLEDGEMENTS

I would like to thank Professor R.G. Thomas (Massey University) for his guidance and interest, and express my grateful appreciation of the enccouragement and helpful criticism I received from Dr. K.J. Mitchell (Plant Physiology Division, D.S.I.R.). I am also indebted to many members of the D.S.I.R. staff for useful discussions.

I wish to thank the technical staff of Plant Physiology Division for their skilled assistance, particularly Mr. J.S. Talbot whose electronic expertise was invaluable.

I am especially grateful to my wife, Carol, for her endless encouragement and understanding: she has a unique knowledge of an aspect of this investigation not reported in these pages.

Finally I thank Mr. P.H. Menalda for his photographic work, and Mrs. Margaret Brogden for typing this thesis.

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