WATER STRESS AND GROWTH AND DEVELOPMENT IN RADISH

by

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TABLE OF CONTENTS

CHAPTER 2. MATERIALS AND METHODS

SUMMARY

The effect of water deficit on the growth and yield of biennial 'root' crops has been studied in some detail. However, little attention has been paid to explaining the underlying mechanisms of observed yield reductions in such crops. With this in mind, Radish was chosen as an example of this group of plants and its response to a range of types, intensities and durations of water stress investigated. The development of the fleshy axis was studied in detail.

Water stress induced with polyethylene-glycol solutions (-5, -10 and -15 bars) resulted in considerable disruption to plant growth. These effects however, were largely of a transient nature. As intensity, and to a lesser extent duration (24, 48 and 72 hr), of stress were increased the reduction of plant growth was increasingly marked until eventually shoot and also fleshy axis death occurred. Tissue death around leaf margins, apparently as a consequence of steep water potential gradients, was a feature of PEG-induced stress. Monitoring of fleshy axis diameter changes throughout stress episodes revealed that water loss was continuous, probably as a consequence of poor stomatal regulation. Repeated episodes of PEG-induced water stress caused highly significant yield reductions.

Water stress imposed through soil water depletion (i.e. water regimes) caused more persistent reductions in Radish plant yield. Again these effects were more marked as stress intensity was increased, and the yield reduction was proportionally greater in fleshy axis than shoot tissue. Both cell division and cell expansion were significantly reduced by stress in both the shoot (reduced leaf area) and the fleshy axis (reduced volume). Although cell division was less obviously decreased by stress than was cell expansion, its reduced rate during stress appeared

to be the primary limitation to plant recovery following stress relief. Cell expansion was more markedly responsive to both imposition and alleviation of stress. The general pattern of fleshy axis cellular differentiation and development was not disrupted even by severe stress, however.

In older plants, the rate of leaf senescence was accelerated by stress, whilst in younger plants only the rate of leaf appearance was reduced. In plants of both ages individual leaf area was decreased. It was determined that older leaves had less ability, possibly because of larger cell sizes and a poorer ability to osmoregulate, than younger leaves to maintain a favourable water balance.

Rapid reduction in leaf water status (PEG treatment) initiated massive proline accumulation. Young, slowly-droughted Radish plants did not display the same considerable reduction in plant water status as did PEG-treated plants and, with time, were able to recommence very slow growth under such conditions. Soluble sugar concentrations in the leaves, cotyledons, hypocotyls and roots of these plants rose, and cell wall thickening in the hypocotyl (through lignin deposition) was observed.

It was concluded that Radish can accomodate single short, episodes of water stress, but that repeated episodes or very severe stress results in a significant yield reduction. The Radish does not have any stage of growth during fleshy axis development which is particularly sensitive to water stress. Long-term depletion of substrate moisture results in reduced plant yield through reduced rates of cell division and inhibited cell expansion. Restoration of a favourable water supply results in a persistent stress effect due to the reduction in cell numbers. When stressed early, before the plant has commenced substantial cell expansion, the Radish can adapt to survive in severely water limited environments.

STATEMENT

I hereby declare that the thesis here presented is my own work, that it contains no material previously published, except where due reference is made in the text, and that no part of it has been submitted for any other degree.

(Daryl C. Joyce)

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LIST OF FIGURES

LIST OF TABLES

ABBREVIATIONS AND SYMBOLS USED IN THIS THESIS

ABA	abscisic acid
$AgNO_3$	silver nitrate
BA	benzyl adenine
^{14}C	radioactive carbon
^{o}C	degrees centigrade
cm	centimetre(s)
cm^2	square centimetre(s)
CO_2	carbon dioxide
cpm	counts per minute
dpm	disintergrations per minute
DNA	deoxyribonucleic acid
FAA	formalin-aceto-alcohol
g	gram(s)
GA_3	gibberellic acid
hr(s)	hour(s)
kg	kilogram
KOH	potassium hydroxide
l	litre
µ	micron(s)
µci	microcurie(s)
µein	microeinstein(s)
µg	microgram
µl	microlitre(s)
MCW	methanol : chloroform : water
mg	milligram(s)
min	minute(s)
MW	molecular weight
MP	melting point
ml	millilitre(s)

ABBREVIATIONS contd.

mm	millimetre(s)
N	normal
NaCl	sodium chloride
Na_2CO_3	sodium carbonate
$NaHCO_3$	sodium bicarbonate
NaOH	sodium hydroxide
nm	nanometre(s)
PEG	polyethylene glycol
RNA	ribonucleic acid
RWC	relative water content
sec	second(s)
W	watt(s)
w/v	weight/volume (concentration)
Ψ	water potential
Ψ_m	matric potential
Ψ_p	turgor potential
Ψ_π	osmotic (solute) potential
*	statistically significant at 95% probability level
%	percent