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**HORTICULTURAL AND PHYSIOLOGICAL ASPECTS OF VIGOUR  
CONTROL IN APRICOT (*Prunus armeniaca* L.) UNDER ORCHARD AND  
CONTROLLED ENVIRONMENT CONDITIONS**

**A thesis presented in partial fulfilment  
of the requirements for the degree of  
DOCTOR OF PHILOSOPHY (Ph.D.)  
in  
Pomology and fruit tree physiology  
at Massey University  
New Zealand**

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**October 1994**

## ABSTRACT

In the absence of dwarfing rootstocks for apricot, techniques which reduce vegetative growth are important in the orchard management system. Studies were conducted in the orchard and in controlled environment (CE) rooms in order to explore the horticultural and physiological responses of apricot (*Prunus armeniaca* L.) to some vigour control techniques.

In the orchard in the humid climate of Palmerston North, New Zealand, five-year-old vigorous 'Sundrop' apricot trees on 'Golden Queen' peach seedlings trained on Tatura trellis at 1000 or 2000 tree ha<sup>-1</sup> were used. The objectives were: a). to evaluate the trees' responses to 0.5 and 1.5 g. tree<sup>-1</sup> soil applied Paclobutrazol (PBZ), dormant root-pruning and regulated deficit irrigation (RDI); b). to identify osmotic adjustment in fruits and leaves in response to internal water stress. Two-year-old 'Trevatt' apricot in an aeroponic system in CE rooms were used with the objectives: a). to examine the effects of root cytokinin and endogenous ABA on shoot growth and whole plant physiology; b). to study the mechanism of adaptation to high water stress.

In the orchard all treatments reduced vegetative growth. PBZ was more effective than the other treatments, and the lower rate (0.5 g. tree<sup>-1</sup>) when applied annually gave more uniform growth reduction. The root-pruning and RDI had less effect, particularly in the second season of study. The deep soil, together with low temperature and evaporation, high rainfall and humid conditions during winter and early spring were limiting factors for RDI. The inhibitory effect of root-pruning was more persistent on wider spaced trees. In close planted trees root length density (RLD) declined with increasing depth, but roots were observed to 1.6 m explored soil depth. Root-pruning increased RLD, but no treatments effect was observed on root weight density (RWD) in the explored soil volume.

PBZ increased dry matter partitioning into crop in both seasons on close

spaced trees, and fruit growth and final fruit size were increased without any detrimental effect on fruit quality. In the second year PBZ advanced flowering by 2-4 days, and increased fruit set, final fruit number, crop density and yield efficiency. In general RDI had no negative effects on flowering, fruiting, yield and final fruit size. In the second year it generally enhanced flowering, fruit set and fruit number. Root-pruning did not affect other flowering and yield parameters, but reduced fruit size in the first season. There was some evidence of advanced fruit maturity and increased total soluble solids by all applied treatments. Generally fruiting characteristics were improved, and vegetative growth reduced, more by PBZ than by root-pruning and RDI.

PBZ treated trees had the same water status as controls. Their net CO<sub>2</sub> assimilation rate (*A*) and stomatal conductance (*g<sub>s</sub>*) were improved, and from later stage I and during stages II and III of fruit growth fruit carbohydrates were increased. RDI and root-pruning increased net CO<sub>2</sub> assimilation rate (*A*) and stomatal conductance (*g<sub>s</sub>*) on some occasions. Root-pruned trees developed an increased internal water deficit in the leaves and fruits especially at the time of highest water demand during fruit stage III. There was evidence on occasions in RDI and root-pruning of osmotic adjustment in leaves and fruits maintaining turgor ( $\Psi_p$ ).

An aeroponic system with intermittent misting gave good control of plant water stress. When water stress was developed gradually plants were able to maintain their turgor at high internal water deficit (-2.2 and -3.0 MPa of  $\Psi_{xylem}$  and  $\Psi_l$  respectively). Osmotic adjustment occurred in both partially and fully expanded leaves of all treatments, BAP combined with water stress showed bigger osmotic adjustment. Water stress reduced vegetative growth, and increased root:shoot ratio. Shoot tip ABA increased as water stress increased. BAP reduced the growth inhibition and rise in shoot ABA of water stressed plants, maintained net CO<sub>2</sub> assimilation rate (*A*) and stomatal conductance (*g<sub>s</sub>*), and increased root:shoot ratio.



*In the Name of ALLAH the Most Merciful the Most Beneficent*

I dedicate this thesis to:

*My parents Haj Mohammad Hassan and Haj Fatemeh Arzani for their patience and moral support; my wife Fatemeh Arzani for her patience, support and encouragement, and my children Ali, Mohsen and Mina Arzani.*

## ACKNOWLEDGMENTS

*In the name of Allah the most gracious and most merciful. First of all praise to Allah for giving me the ability to learn. This study would not have been possible without the help of Allah s.w.t.*

I would like to express my deepest gratitude and sincere thanks to my supervisors Dr. David Wood and Dr. Stephen Lawes for their guidance, encouragement and criticism. I am grateful and indebted to their patience, enthusiastic encouragement and comments and close supervision throughout the course of this study. They never got tired answering my questions and I was provided with friendly answers at any time that I needed their help. I would like also to express my thanks to Dr. Hugo Varela-Alvarez my co-supervisor (Computer Centre, Massey University) for his discussion in planning the experiments, data analysis and reviewing the manuscript.

I wish to express my thanks to Prof. David Chalmers for his comments and discussion during the first year of orchard study (as a co-supervisor) and also his comments on the controlled environment experiment. I would like to thank Dr. Hossein Behboudian for his comments on the water relations study and reviewing chapters 2 and 6 of this thesis. I wish to thank Dr. David Woolley for his comments at the time of preparing the proposal for the controlled environment study, his suggestions on ABA analysis, and his review and comments on chapter 7 are acknowledged. I wish also to thank Dr. Keith Hughes for his assistance in root core sampling in the orchard study and his comments on presenting the results of root study and reviewing chapter 4. Thanks are extended to Mr. Bruce Mackay for answering my questions and his suggestions regarding statistical analysis.

I greatly appreciate the help from the staff of the Plant Growth Unit, especially Mr. Ray Johnstone and Mr. Charles Forbes. The assistance of Mr. Dean Pegler throughout the orchard, glasshouse and controlled environment experiments is gratefully recognised. Thanks to Mr. Giles Russell for his

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excellent help in monitoring the aeroponic and hydroponic systems used. I would also like to express my thanks to the staff of the Fruit Crops Unit for their management of the experimental trees and their assistance in summer pruning and harvesting. I thank the management and staff of the Crown Research Institute (Hort+Research) for organising the climate rooms, in particular Mrs. Liz Halligan, Mrs. Linda Robinson and Mr. Len Ruby, operations technician. I greatly appreciate the AgResearch (CRI) providing me with climatological data of the experimental site.

I am very grateful to the staff and postgraduate students of the Plant Science Department for their help and providing a friendly environment throughout this study. I would mention particularly the friendship of Paul Austin and Guillermo Cruz-Castillo, and gratefully acknowledge the technical assistance of Colin Tod, Chris Rawlinton, Jonathan Dixon and Hugh Neilson when I was working in the laboratory. I greatly appreciated the assistance of Mike Currie in synthesising ABA-BSA conjugate.

The presence of all the other Iranian postgraduate students and their families in Palmerston North made my family and I feel at home. It is my pleasure to thank and wish them a happy and prosperous future.

I gratefully acknowledge the University of Tarbiat-Modarres and the Ministry of Culture and Higher Education of Iran, for awarding me the scholarship to undertake this study.

And last, but certainly not least, my sincere thanks are due to my wife Fatemeh Arzani for her patience, support and encouragement throughout my study and her excellent effort to educate our children. The patience, of my sons Ali and Mohsen and my daughter Mina and their encouragement and understanding have encouraged me to cope with difficulties.

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## GLOSSARY OF ABBREVIATIONS

A	net CO <sub>2</sub> assimilation rate ( $\mu\text{mol m}^{-2} \text{s}^{-1}$ )
ABA	abscisic acid
a.i.	active ingredient
BAP	6-benzylaminopurine
BAP+WS	6-benzylaminopurine with water stress induced by intermittent misting
BSA	bovine serum albumin
CE	controlled environment
CD	crop density (fruit number $\text{cm}^{-2}$ TCSA)
CHO	carbohydrate
cv.	cultivar
Cultar <sup>®</sup>	Paclobutrazol formulation
dafb	days after full bloom
dae	days after establishment
dats	days after treatment started
DW	Dry weight
DWI	stage I of fruit growth based on dry weight
DWII	stage II of fruit growth based on dry weight
DWIII	stage III of fruit growth based on dry weight
EC	electrical conductivity (mS)
ELISA	enzyme linked immunosorbent assay
E <sub>ps</sub>	evaporation over the planting square
E <sub>pan</sub>	pan evaporation
ET <sub>crop</sub>	crop water requirement ( $\text{mm day}^{-1}$ )
ET	evapotranspiration
FC	field capacity
FGR	fruit growth rate ( $\text{mm, g. or cm}^3 \text{ day}^{-1}$ )
FT <sub>2</sub>	fruit size at time 2 ( $\text{mm, cm}^3 \text{ or g.}$ )
FT <sub>1</sub>	fruit size at time 1 ( $\text{mm, cm}^3 \text{ or g.}$ )
FW	initial fresh weight (g),
GA <sub>3</sub>	gibberellic acid

GLM	General Linear Model
$g_s$	stomatal conductance ( $\text{m mol m}^{-2} \text{ s}^{-1}$ )
H-PBZ	high rate of Paclobutrazol ( $1.5 \text{ g tree}^{-1}$ )
HPLC	high performance liquid chromatography
IAA	indole-3-acetic acid
ICI	Imperial Chemical Industries Ltd
J	water flux density ( $\text{g m}^{-2}\text{s}^{-1}$ )
$L^*$	lightness (refers to colour)
$\ell$	total root length (cm)(refers to root study)
LAR	leaf area ratio (ratio of total leaf area to whole plant dry weight, $\text{m}^2 \text{ g}^{-1}$ )
L-PBZ	low rate of Paclobutrazol ( $0.5 \text{ g tree}^{-1}$ )
MAb	Monoclonal antibody
MPa	mega pascal ( $1\text{Mpa} = 10 \text{ bar}$ )
NF	total number of fruits at the time of fruit harvest
NFT	nutrient film technique
$n \text{ mol}_{cho}$	moles of solute (refers to Van't Hoff's equation)
NZ	New Zealand
PBZ	Paclobutrazol
P.E.	pan evaporation
PEG	polyethylene glycol
P-index	partitioning index ( $\text{kg yield cm}^{-2} \text{ TC SA year}^{-1}$ )
PNP	<i>p</i> -nitrophenyl phosphate
PP333	paclobutrazol
PPFD	photosynthetic photon flux density ( $\mu\text{mol m}^{-2} \text{ s}^{-1}$ )
PVP	Insoluble Polyvinylpyrrolidone
R	the universal gas constant (refers to Van't Hoff's equation)
$r$	distance from tree (refers to root study)
$r$	resistance to diffusion of water between $\Psi_{w1}$ and $\Psi_{w2}$
RCBD	randomized complete block design
RDI	regulated deficit irrigation

Rdwt	dry weight of fine or woody roots (g)
RH	Relative humidity (%)
RLD	root-length density (cm of roots cm <sup>-3</sup> of soil)
RM	repeated measurement analysis
RPM	revolutions minute <sup>-1</sup>
RWD	root-weight density (g of roots cm <sup>-3</sup> of soil)
RWC	relative water content (%)
Savant	automatic Speedvac concentrator
TSS	total soluble solids
T	fruit temperature in °K (refers to Van't Hoff's equation)
TBS	buffer containing Tris, MgCl <sub>2</sub> and NaCl
TBST	washing buffer TBS containing 0.05% (v/v) Tween 20, and 0.1% (w/v) BSA
T <sub>2</sub>	time 2 (day)
T <sub>1</sub>	time 1 (day)
TCSA	trunk cross sectional area (cm <sup>2</sup> )
TCSA GR	growth rate of trunk cross sectional area (cm <sup>2</sup> year <sup>-1</sup> )
TCSA <sub>t<sub>2</sub></sub> & t <sub>1</sub>	TCSA recorded at time 2 (t <sub>2</sub> ) and time 1 (t <sub>1</sub> )
TY	total harvested fruit tree <sup>-1</sup> (g.)
TW	turgid weight (g)
V	volume of solvent in litres (refers to Van't Hoff's equation)
V	soil sample volume (cm <sup>3</sup> )(refers to root study)
V <sub>o</sub>	osmotic volume at full turgor
VPD	vapour pressure deficit (mb)
WS	water stress induced by intermittent misting
WSb	water stress induced with intermittent misting (see 7.2.5.2)
YE	yield efficiency (g. of fruit cm <sup>-2</sup> TCSA)
z	depth to midpoint of sample (refers to root study)
Ψ <sub>cho</sub>	osmotic pressure (MPa) of each individual recorded carbohydrate (refers to Van't Hoff's equation)
Ψ <sub>f</sub>	fruit water potential

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$\Psi_g$	gravitational potential
$\Psi_{\text{glucose}}$	osmotic pressure of glucose (the partial contribution of glucose in osmotic adjustment)
$\Psi_l$	leaf water potential
$\Psi_m$	matric potential
$\Psi_p$	turgor or pressure potential
$\Psi_s$	osmotic potential
$\Psi_{So}$	osmotic potential at full turgor
$\Psi_w$	water potential
$\Delta\Psi_w$	water potential difference between two points ( $\Psi_{w1} - \Psi_{w2}$ )
$\Psi_{\text{xylem}}$	xylem water potential
$\theta$	angle relative to row direction (refers to root study)