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# **Manipulation of canopy architecture and possible vigour control mechanisms in kiwifruit**

**A thesis presented in partial fulfilment of the requirements for the degree of**

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**MASSEY UNIVERSITY**  
**TE KUNENGA KI PŪREHUROA**  

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**UNIVERSITY OF NEW ZEALAND**

**Fadhilnor Abdullah**

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## Abstract

Dwarfing or vigour-controlling rootstocks have been used in many fruit trees to reduce scions growth, improve precocity and yield efficiency, but they are not currently available for kiwifruit. Therefore, there is a strong need to evaluate the vigour-controlling rootstocks and/or other growth manipulation techniques for controlling excessive growth of kiwifruit. In this study, the initial growth and architecture of ‘Hayward’ scions may have been modified by the inter-specific hybrid kiwifruit rootstocks, during the first- and second- year of growth following grafting. Rootstocks modified the trunk cross-sectional area and proleptic bud break of the ‘Hayward’ primary shoots. The lengths of long and short proleptic shoots of the scions from particular rootstocks were also slightly reduced, thus reducing the total length of proleptic shoots on grafted scions. In the field, inter-specific hybrid kiwifruit rootstocks affected the duration and compactness of scions bud break. The most notable effect of hybrid rootstocks was on the growth rate of long proleptic axillary shoots of scions during early spring growth with ‘Hayward’ scions on particular rootstocks had the slowest growth rate compared to other rootstocks. Rootstocks may affect scions floral precocity, with ‘Hayward’ scions on particular kiwifruit rootstocks tended to produce higher flower numbers when they were first planted on the field. There was a strong trend that rootstocks affected the proportion of long shoots and this effect had contributed to the differences in the proportion of non-terminated and terminated shoots of the scions. Auxin transport inhibitor, 1-N-naphthylphthalamic acid (NPA) applied to the stem junction at graft-union on some rootstocks had decreased the length, node number and cross-sectional area of scion primary shoots. However, NPA treatment on particular rootstocks did not affect the growth of scion primary shoots on some of the rootstocks, suggesting that restriction of IAA did not influence the level of IAA transported from shoot to root system of those kiwifruit rootstocks. NPA reduced the leaf size of scions, indicating that sufficient IAA is needed for the leaf growth of kiwifruit, but it may be regulated by the rootstocks. The transport and uptake of radioactivity of IAA in the stem segment varied between the rootstocks, suggesting that the level of IAA in the stem tissues of inter-specific hybrid kiwifruit rootstocks may vary depending on the vigour and genetics of the kiwifruit rootstocks. Restriction of IAA by inverting a single piece of bark (180-degree orientation) and grafted back to the main stem did not completely reduce the vigour of young ‘Hort16A’ vines. However,

the growth and vigour of young 'Hort16A' vines in terms of total length, total node number and total leaf area were greatly reduced when grafted three rings of bark from other cultivars in an inverted orientation. In the field, the bark grafting treatments along with girdling were evaluated to regulate the characteristics of 'Hayward' fruits. All treatments did not consistently produce similar effects in each season and year. Comparison between treatment, season (i.e. early and late summer) and year indicated that the treatment effects on fruit fresh weight, dry weight and dry matter concentration were only evident in the first harvesting year, and the effects were lessened in the following year. In this study, four distinct phenotypes were found from the kiwifruit seedlings population based on their main primary shoots; i) Long Multiple Stems (LMS), ii) Short Multiple Stems (SMS), iii) Long Single Stem (LS), and iv) Short Single Stem (SS). Gibberellins ( $GA_3+GA_{4+7}$ ) treatment on these phenotypes at an early stage of bud break has transformed the morphology and characteristics of proleptic axillary shoots. The mean total number of proleptic and sylleptic axillary shoots (i.e. branching) was increased with gibberellins treatment, suggesting that gibberellins can promote meristematic activity by regulating both apical and sub-apical meristem of kiwifruit shoots.

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*“I begin by naming and remembering Allah Almighty, seeking His help in everything, asking Him alone for support in all of my affairs. Indeed, He is the Lord, the One worshipped, His favours are many and Great, His generosity is vast, and His mercy encompasses all creatures.”*

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## List of abbreviations

A.D.	Anno Domini
ABA	Abscisic acid
ANCOVA	Analysis of covariance
ANOVA	Analysis of variance
BAP	Benzylaminopurine
CCD <sub>n</sub>	Carotenoid Cleavage Dioxygenase <sub>n</sub> denotes the number
CG.4213	Cornell-Geneva 4213
CG.7037	Cornell-Geneva 7037
CG.8534	Cornell-Geneva 8534
CK	Cytokinins
cm	Centimetre
CO <sub>2</sub>	Carbon dioxide
cv.	Cultivar
CSA	Cross-Sectional Area (mm <sup>2</sup> )
DMC	Dry matter concentration
dpm	Disintegrations per minute
EMLA.27	East Malling/Ashton Long 27
G.16	Geneva 16
G.935	Geneva 935
GA	Gibberellins
GA <sub>n</sub>	Gibberellin <sub>n</sub> denotes the number
GLM	General linear model
GM1	Growth manipulation 1
GM2	Growth manipulation 2
GM3	Growth manipulation 3
GN	Green cuttings (self-rooted control)
GR24	Synthetic strigolactones
h	Hour
Hi-Cane	Hydrogen cyanamide
HV	High-Vigour rootstock group
IAA	Indole-3-acetic acid
IBA	Indole-3-butyric acid
IV	Intermediate-Vigour rootstock group
K	Kalium
L	Litre
LAI	Leaf Area Index
LMA	Leaf Mass per Area
LMS	Long Multiple Stems
LS	Long Single Stem
LSD	Least Significant Difference
LV	Low-Vigour rootstock group
lsmeans	Least square means
m	Meter
MAX	More Axillary Growth ( <i>n</i> ) denotes the number
M.104	Merton 104
M.16	Malling 16
M.793	Malling 793
M.9	Malling 9
mm	Millimetre
MM.106	Malling Merton 106
MM.111	Malling Merton 111
MM.25	Malling Merton 25
MM.27	Malling Merton 27
N	Nitrogen
NAA	1-Naphthaleneacetic acid
No.	Rootstock number
NPA	1-N-naphthylphthalamic acid

O <sub>2</sub>	Oxygen
P	Phosphorus
PCA	Principal Component Analysis
PFR	Plant and Food Research
PGU	Plant Growth Unit
PGR	Plant Growth Regulator
PSA	<i>Pseudomonas syringae</i> pv. <i>Actinidiae</i>
QTLs	Quantitative Trait Loci
RCBD	Randomised Completed Block Design
SAM	Shoot Apical Meristem
SAS	Statistical Analysis System
SLs	Strigolactones
SMB	Short Multiple Stems
spp.	Species
SS	Short Single Stem
TIBA	2,3,5,-Triiodobenzoic acid
UK	United Kingdom
USA	United State of America
VLV	Very Low-Vigour rootstock group
[ <sup>14</sup> C]-IAA	Carboxyl-labelled indole-3-acetic acid
[ <sup>14</sup> H]-IAA	Tritiated-labelled indole-3-acetic acid

## Defination of terms

<b>TERM</b>	<b>DEFINATION</b>
<b>Proleptic shoots</b>	The shoots that developed from buds which has been dormant for some period of time. The leaves scale usually enclose the bud.
<b>Sylleptic shoots</b>	The shoots that developed from lateral buds with any period of dormancy. The leaves scale do not usually enclose the bud.
<b>Girdling</b>	The completely removal of a strip of bark around the entire circumference of a vines (consisting of cambium or phloem).
<b>Phenology</b>	The scientific study of periodic biological phenomena (e.g. shoot, flowering and fruiting stage).
<b>Precocity</b>	The ability of fruit trees or vines to induce fruitfulness without the need for completing the juvenile phase.
<b>Bud break</b>	The opening of a dormant bud when the shoot begins to grow and usually during early spring.
<b>Phenotype</b>	The physical appearance, observable characteristics or particular traits (e.g. plant morphology).
<b>Genotype</b>	The set of genes, which is responsible for a particular trait.
<b>Long shoots</b>	The kiwifruit shoots that have a number of neofomed nodes and the total number of nodes per shoot is up to 90, and non-terminated.
<b>Medium shoots</b>	The kiwifruit shoots that have more than nine nodes and terminated.
<b>Short shoots</b>	The kiwifruit shoots that have nine or less nodes and terminated.
<b>Clonal rootstock</b>	A vegetatively propagated or cloned rootstock as opposed to a germinated seedling rootstock.
<b>Leader pruning</b>	Pruning or removing all vigorous vegetative shoots that closed to the central leader of kiwifruit vines.

## List of publications and conferences

- Abdullah, F.** and Woolley, D. J. (2012). Effects of bark inversion on fruit weight, size and dry matter concentration of green kiwifruit (*Actinidia deliciosa* cv. 'Hayward'). *Acta Horticulturae*, 1012, 213-218.
- Abdullah, F.**, Woolley, D.J., B.M. van Hooijdonk and A.P. Friend (2012). Effect of bark insert-grafting on initial shoot architecture and vegetative growth of newly-propagated gold kiwifruit cv. 'Hort16A'. Poster paper presented in 10<sup>th</sup> International Symposium on Integrating Canopy, Rootstock and Environmental Physiology in Orchard Systems. South Africa, 2012. (Part of Chapter 5)
- Abdullah, F.**, Woolley, D.J., B.M. van Hooijdonk and A.P. Friend (2013). Control of vegetative vigour and crop architecture in kiwifruit. Oral paper presented in New Zealand Institute of Agriculture and Horticulture Plant Science Conference 2013, Massey University, Palmerston North, New Zealand. 2-4 July 2013. (Part of Chapter 2)
- Abdullah, F.**, Woolley, D.J., K.A. Funnell, B.M. van Hooijdonk and A.P. Friend (2013). Preliminary observation on the initial architecture of kiwifruit seedlings obtained from specific crosses. Poster paper presented in New Zealand Institute of Agriculture and Horticulture Plant Science Conference 2013, Massey University, Palmerston North, New Zealand. 2-4 July 2013. (Part of Chapter 6)
- Abdullah, F.**, Woolley, D.J., B.M. van Hooijdonk and A.P. Friend (2015). Interspecific hybrid kiwifruit rootstocks have potential to modify scion architecture and vigour of young 'Hayward' vines. *Acta Horticulturae*, 1096, 241-246. (Chapter 2)