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**Vigour Control in Apple (*Malus domestica*) and
Kiwifruit (*Actinidia deliciosa* and *Actinidia chinensis*)**

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Doctor of Philosophy
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Noveline Mercy Rose Gali Vattiprolu

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Abstract

Recent knowledge suggests the physiological basis of scion vigour control by dwarfing apple rootstocks involves shoot-root-shoot hormonal signalling. An aim of the present study was to further explore the role of gibberellin in control of apple (*Malus domestica*) scion vigour on a dwarfing rootstock and also an attempt was made to elucidate whether a generalised signalling mechanism exists in kiwifruit vines. For commercially grown kiwifruit (*Actinidia deliciosa* and *Actinidia chinensis*), there have been no studies on whether gibberellins stimulate the vigorous shoot growth that normally occurs.

For apple, dwarfing rootstocks of Malling Nine ('M.9') and vigorous rootstocks 'Royal Gala' ('RG') were grafted with scions of 'M.9' or 'RG' using a reciprocal grafting treatment structure. The 'M.9' rootstock increased the proportion of 'RG' primary shoots that terminated early with reduced growth rate and plastochron while exogenous gibberellins partially reversed the effect by stimulating both apical and sub-apical meristems and prolonging shoot extension, thus suggesting that 'RG' scions on 'M.9' rootstocks were deficient in bioactive gibberellins. The gibberellin foliar sprays increased the internode length by acting on cell division primarily and on cell elongation secondarily. The 'M.9' shoots of apple are short with reduced node number and early termination compared to vigorous 'RG' plants. This low vigour phenotype was maintained even on the vigorous rootstock, 'RG'. Foliar sprays of GA₃+GA₄₊₇ to the scion did not reverse the primary or sylleptic shoot growth of 'M9' scion, which suggests that 'M.9' may be unable to convert exogenous gibberellins to bioactive GA₁. For kiwifruit, the auxin transport inhibitor 1-N-naphthylphthalamic acid (NPA) applied to the stem of young rooted stem cuttings of *Actinidia chinensis* 'Hort16A' significantly reduced primary shoot length but the architectural changes imposed were different from those of NPA applied to apple. For apple, both NPA and a dwarfing rootstock reduced number and length of sylleptic axillary shoots (SAS) on the primary shoot and caused early termination of both SAS and primary shoots, whereas for kiwifruit NPA did not have any effect on total shoot growth compared with control. Given these dissimilarities, it was proposed the reduction of indole-3-acetic acid (IAA) to the root system of kiwifruit may not affect shoot growth through an effect on root-produced hormones. However, more work is needed using different auxin transport inhibitors to evaluate the effect of auxin restriction to the root system on root-produced hormones.

Foliar sprays of 1-naphthaleneacetic acid (NAA) and NPA reduced total shoot length of kiwifruit 'Hayward', possibly due to supra-optimal synthetic auxin levels for NAA and low levels of natural auxin levels for NPA in kiwifruit stems respectively. Foliar sprays of 500-1000 mg L⁻¹ gibberellins (GA₃+GA₄₊₇) applied to mature 'Hayward' vines was found to be optimum for stimulating vigorous shoot growth. Since the anti-gibberellin prohexadione-Ca, decreased kiwifruit shoot growth, it may be possible to use this compound commercially to control excessive vegetative growth. As this anti-gibberellin inhibits the action of enzyme GA₂₀ oxidase, which promotes the ultimate step of converting GA₂₀ and GA₁₉ to GA₁ in GA-biosynthesis pathway, it may also be possible to suppress the expression of gene encoding GA₂₀ oxidase with the help of molecular biology techniques or produce better rootstock by conventional breeding.

Gibberellins activity in stimulating apical and sub-apical meristem is the most important event involved in shoot extension growth of kiwifruit and apple. For both kiwifruit and apples exogenous gibberellins inhibited flowering. For composite apple tree rather surprisingly, the 'RG' rootstock promoted flowering for 'RG' scion whereas 'M.9' rootstock reduced flowering. For kiwifruit, BAP promoted a high percentage of synchronised bud breaks. For both apple and kiwifruit gibberellins GA₃+GA₄₊₇ appeared to stimulate sylleptic axillary shoot formation. For kiwifruit the possibility exists to select low vigour seedling, increase their vigour with gibberellins during the establishment phase, and then decrease vigour by withholding gibberellins once the canopy is established.

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List of abbreviations

ABA	Abscisic acid
AD	Apical dominance
ANOVA	Analysis of variance
ARD	Apple Replant disease
ATA	Auxin transport auto inhibition
ATIs	Auxin transport inhibitors
BA	Benzyl adenine
BAP	Benzylaminopurine
[¹⁴ C]-IAA	Carboxyl-labelled indole-3-acetic acid
CLSM	Confocal laser scanning system
<i>CLV</i>	<i>CLAVATA</i>
CU	Chilling unit
CZ	Central zone
2-D	Diode-pumped solid state
FAA	Formalin: acetic acid: alcohol
G	Girdling
G.16	Geneva 16
GA (Feb)	Gibberellins applied from February
GA (Nov)	Gibberellins applied from November
GA ₂₀ <i>oxi</i>	GA ₂₀ Oxidase enzyme
GA _n	Gibberellin _n denotes the number
GAs	Gibberellins
GDC	Geneva double curtain
GLM	General linear model
³ H-IAA	Tritiated Indole-3-acetic acid
HRI	Horticultural Research Institute
2ip	Isopentenyladenine

IBA	Indole butyric acid
IPTs	Adenosine phosphate-isopentenyl transferases
IAA	Indole-3-acetic acid
JM	Japanese apple rootstock
<i>KNOX</i>	<i>KNOTTED1</i> -like homeobox
LAI	Leaf area index
LSD	Least square means
lsmeans	Least square means
M.793	Merton 793
M.9	Malling 9
MeOX	3-methyleneoxindole
MJ m ⁻²	milliJoule per square metre
MM.106	Malling Merton 106
MPa	Mega Pascal(s) (1 MPa = 10 bars)
NAA	1-naphthalene acetic acid
NPA	1-N-naphthylphthalamic acid
PAT	Polar auxin transport
PGR	Plant growth regulators
PBZ	Paclobutrazol
PIN1	<i>Pin-protein</i>
PSA	<i>Pseudomonas syringae pv. actinidae</i>
PVC	Poly vinyl chloride
PZ	Peripheral zone
RB	Royal Beauty
RCBD	Randomised complete block design
RDI	Regulated deficit irrigation
RG	Royal Gala
RMS _n	Ramosus _n denotes the number
RR	Root restriction

SADH	Succinic acid dimethyl hydrazide
SAM	Shoot apical meristem
SARD	Specific Apple Replant Disorder
	Sylleptic axillary shoot
SAS	OR
	System for statistical analysis
SCA	Shoot cross-sectional area
SL	Strigolactones
SS	Sylleptic shoots
STK	Starkrimson
<i>STM</i>	Shootmeristemless
TG	Trunk girdling
TIBA	2,3,5-Triiodobenzoic acid
USDA	United State Department of Agriculture
WAA	Woolly aphid disease
<i>WUS</i>	<i>WUSCHEL</i>
Z	Zeatin
ZR	Zeatin riboside

