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SHOOT-ROOT ALLOMETRY AND GROWTH OF NASHI AND TOMATO: EFFECTS OF BUDDING, GIBBERELLINS AND CYTOKININS

SUREERAT THUANTAVEE

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SHOOT-ROOT ALLOMETRY AND GROWTH OF NASHI AND TOMATO : THE EFFECTS OF BUDDING, GIBBERELLINS AND CYTOKININS

A thesis presented in partial fulfilment
of the requirements for the degree of
DOCTOR OF PHILOSOPHY
in
Horticultural Science
at Massey University

Sureerat Thuantavee
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ABSTRACT

Growth of the root and the shoot systems of plants is generally, positively correlated, although the mechanism(s) controlling such relationships is not well understood. A series of experiments were carried out on young nashi trees (*Pyrus serotina*) and tomatoes (*Lycopersicon esculentum* Mill.) to explore this homeostatic phenomenon.

Two nashi cultivars, Hosui and Nijiseiki, were budded on to each of three clonal rootstocks, which differed in vigour (scion-budded trees). Buds from each rootstock was also budded on their own roots (rootstock trees). Growth, measured by individual organ and total plant dry weight, leaf attributes (leaf area, leaf number and leaf size) and root attributes (root length, root number and root volume) over two years after budding, indicated that scion-budded trees were markedly smaller than rootstock trees, irrespective of rootstock vigour. The imbalance of shoot-root ratio occurred following pruning after bud take; this remained in rootstock trees for one year but persisted for two years in scion budded trees. Vigour of all rootstocks appeared to diminish with time and final tree size was not well related to initial rootstock vigour. Neither rootstock nor scion morphological characteristics appeared to be changed by the partner, although presence of the cultivar bud on rootstocks delayed commencement of root activity in early spring. These results indicate that two-year-old (scion budded growth) nashi trees are not appropriate material for studying allometric relationship.

Plant growth regulators, gibberellins and cytokinins, were applied to 6- and 5-week-old tomato seedlings, respectively, in three separate aeroponic experiments. Gibberellic acid was sprayed twice to the shoot (at 2.9×10^{-5} M), while root application was achieved by incorporating GA_3 into the nutrient solution (conc. 5.8×10^{-5} and 2.9×10^{-4} M). Compared to the control, stem elongation, stem dry weight and stem weight ratio (SWR) was increased while root attributes (dry weight and root weight ratio (RWR)), leaf attributes (leaf area, leaf area ratio and leaf dry weight), and consequently total plant dry weight were reduced in GA_3 treated plants.

Gibberellic acid promoted apical dominance. Shoot applied GA_3 was quantitatively more effective than root application, suggesting that the organ in which physiologically active GA(s) originate may be an important component of plant response to environments. In addition, GA_3 effects were additive as indicated by the increasing difference with time in SWR and shoot-root ratio. The increased SWR and reduced leaf weight ratio (LWR) were responsible for an increase in the allometric value between stem and root dry weight (k_S), and a reduction in the allometric value between leaf and root dry weight (k_L), respectively. However, allometric value between shoot and root dry weight (k_T) was unaltered by GA_3. These results suggest no feedback mechanism of *de novo* GA synthesis occurred, and indicate that GA has no role in regulation of shoot-root allometry.

A synthetic cytokinin, benzylaminopurine (BA), was applied to roots at 2.2 $X10^{-8}$, 2.2 $X10^{-7}$ and 2.2 $X10^{-6}$ M. The control gave an intermediate response in all parameters measured, compared to the enhanced response at 2.2 $X10^{-8}$ M BA and the inhibitory response at other BA concentrations. This suggested that BA supplemented, and had a similar effect to, endogenous cytokinins. Benzylaminopurine initially or transiently stimulated shoot and leaf primordia and thus released buds from apical dominance, leading to an increase in leaf attributes (leaf number, leaf area, leaf dry weight and leaf weight ratio (LWR)), increased shoot-root ratio and reduced RWR. Benzylaminopurine had no effect on stem attributes (stem elongation, stem dry weight and SWR). There were, however, no changes induced in k_L and k_T. It is suggested that cytokinins participate in the homeostatic mechanism regulating plant growth allometry.

A model in which both gibberellins and cytokinins integrate to affect plant growth via allometric relationships is proposed. The usefulness of allometric studies to detect and analyse dynamic changes of organs and plant productivity in response to environment, as well as explain mechanisms regulating shoot-root equilibrium is strongly endorsed by this study.

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LIST OF ABBREVIATIONS

BA	=	Benzylaminopurine.
d.wt.	=	Dry weight (g).
GA(s)	=	Gibberellins.
GA_3	=	Gibberellic acid.
k	=	Allometric value or allometric constant or allometric cefficient (the slope of a regression of ln y = ln a + k ln x, where y is either leaf, stem or shoot dry weight and x is root dry weight).
k_L	=	Allometric value for the regression line of ln (leaf d. wt.) = ln a + k_L ln (root d. wt.).
k_S	=	Allometric value for the regression line of ln (stem d. wt.) = ln a + k_S ln (root d. wt.).
k_T	=	Allometric value for the regression line of ln (shoot d. wt.) = ln a + k_T ln (root d. wt.).
LA	=	Total leaf area (cm^2).
LAR	=	Leaf area ratio (ratio of total leaf area to whole plant dry weight, $cm^2.mg^{-1}$).
LWR	=	Leaf weight ratio (ratio of total leaf dry weight to whole plant dry weight, in percentage).
RWR	=	Root weight ratio (ratio of total root dry weight to whole plant dry weight, in percentage).
RGR(s)	=	Mean relative growth rate (refer to page 42, $g.g^{-1}.day^{-1}$).
RGR_L	=	Relative growth rate of total leaf dry weight ($g.g^{-1}.day^{-1}$).
RGR_S	=	Relative growth rate of total stem dry weight ($g.g^{-1}.day^{-1}$).
RGR_T	=	Relative growth rate of total shoot dry weight ($g.g^{-1}.day^{-1}$).
RGR_R	=	Relative growth rate of total root dry weight ($g.g^{-1}.day^{-1}$).
RGR_W	=	Relative growth rate of whole plant dry weight ($g.g^{-1}.day^{-1}$).
RGR_{LR}	=	Ratio of leaf to root relative growth rate (RGR_L/ RGR_R).
RGR_{SR}	=	Ratio of stem to root relative growth rate (RGR_S/ RGR_R).
RGR_{TR}	=	Ratio of shoot to root relative growth rate (RGR_T/ RGR_R).

RGR_{SL}	=	Ratio of stem to leaf relative growth rate (RGR_S/ RGR_L).
se	=	Standard error of mean, unless state otherwise.
shoot	=	Over-ground part of plants, consisting of stem and leaves (g).
SLA	=	Specific leaf area (ratio of total leaf area to whole leaf dry weight, $cm^2.mg^{-1}$).
SWR	=	Stem weight ratio (ratio of total stem dry weight to whole plant dry weight, in percentage).