# ASPECTS OF FRUIT GROWTH AND ROOTSTOCK / SCION INFLUENCE ON FIELD PERFORMANCE IN KIWIFRUIT (*Actinidia deliciosa* (A. CHEV.) C.F. LIANG et A.R. FERGUSON var. *deliciosa*).

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## ABSTRACT

The influence of nine *Actinidia deliciosa* (A. Chev.) C.F. Liang *et* A.R. Ferguson var. *deliciosa* rootstocks and four 'Hayward' strains on the growth and cropping performance of kiwifruit vines four, five, and six years after grafting was determined. Multivariate analysis of variance on phenotypic data was an effective technique to distinguish main effects of rootstock and scion and the interactions between the two. Canonical Variate Analysis was particularly useful for distinguishing between root systems, 'Hayward' selections and their interaction on the basis of field performance. This statistical technique was highly effective in summarizing the complex relationships of the data and provided a useful method of reducing the dimensionality of the problem. A rootstock effect on plants topworked on root system 4 (male) was characterised by high field performance, as expressed by high floral bud burst and high yield of large size fruit in each of three seasons. Own rooted vines had the highest field performance in one season. Own rooted 'Hayward' B strain had a large trunk diameter and high yield in comparison to the other three own rooted 'Haywards', in two seasons. In contrast, when strain 'B' was topworked across eight root systems the vines produced a low yield of small fruit in two seasons. 'Hayward' A as a scion achieved the best field performance in yield and fruit sizing across eight root systems in two seasons. Root system and scion interactions were characterised by differences in 'Hayward' selection effects on individual root systems, and root system effects on individual 'Hayward' selections. In particular scion performance on root system 9 differed significantly, as did the effect of rootstock on the scion selection 'Hayward' D.

Fruit from some vines had a significant increase in percentage of soluble solids and fruit firmness at harvest, and during storage. Scion effects on percentage of soluble solids present at harvest were lost after fifteen weeks of cold storage. Conversely, in some cases, significant interaction between rootstock and scions on that variate were found only after a period of fruit storage. Rapid fruit softening during storage occurred in some rootstock scion combinations, particularly 'Hayward' C on its own roots and three of the eight rootstocks.

The effects of early summer partial defoliation on fruit size, return bloom, and carbohydrate content of 'Hayward' kiwifruit vines were studied. An arbitrary distinction was made between shoots arising from the 'replacement cane zone' (RCZ), the wide horizontal area between the T-bar support wires, and the fruiting zone (FZ), comprising all growth arising outside the T-bar support wires. A 75 % defoliation of new shoots in the RCZ significantly reduced mean fruit size 13 and 7 g, in the RCZ and FZ, respectively, and starch content of the shoots as determined in March. The treatments did not significantly alter the root starch content over several dates sampled. The return bloom of the vines was significantly reduced by 50 and 75 % defoliation.

Pre-anthesis factors and early fruit growth were important in determining final fruit size. Ovaries from early opening flowers had significantly greater fresh weight than late ovaries. Cell number and cell size in the inner and outer pericarp of the ovary at anthesis were similar for early and late opening flowers but core cell number was significantly higher for ovaries from early flowers. At commercial

harvest, the cell number in the outer pericarp of fruit from early flowers was greater than fruit from late flowers. When treated with the synthetic cytokinin CPPU (N-(2-chloro-4-pyridil)-N-phenylurea), fruit from early flowers achieved a larger fruit size than fruit from late flowers.

Fruit weight response to the synthetic cytokinin CPPU was enhanced when applied in combination with $GA_3$ (gibberellic acid) + 2,4-D (2,4-dichlorophenoxyacetic acid) in three seasons. In treated 'Hayward' fruit, the relative thickness of the outer pericarp was increased, and the inner pericarp decreased. Low and high seeded fruit treated with the hormone mixture had mean fresh weights of 102 and 136 g, respectively, compared with 47 and 90 g in untreated fruit. In kiwifruit inner pericarp cultured *in vitro* there was no callus growth in the absence of hormones, even when seed were present. A mix of 2,4-D + $GA_3$ + BAP (6-benzylaminopurine) stimulated callus growth. In the presence of 2,4-D + $GA_3$, seeds or BAP increased fruit callus growth and reduced the phytotoxicity effect of abscisic acid (ABA).

The uptake of $^{14}$C-CPPU and $^{14}$C-CPPU + 2,4-D + $GA_3$ by 'Hayward' kiwifruit, and the distribution of radioactive label in fruit tissues was examined. After 21 days the recovery of radioactivity was significantly greater from fruit treated with mixture compounds to CPPU alone. At commercial harvest radio-active metabolites of CPPU were on average 6.2 and 4.8 ppb (fresh weight basis) for soluble and insoluble acetone fractions, respectively. Of this activity, 90 % was present on the skin, and 10 % in the flesh.

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# TABLE OF CONTENTS

# LIST OF TABLES

**CHAPTER 3**

**CHAPTER 4**

**CHAPTER 6**

## LIST OF FIGURES

**CHAPTER 4**



**CHAPTER 7**

# CHAPTER 1.

## GENERAL INTRODUCTION.

Kiwifruit (*Actinidia deliciosa* (A. Chev.) C.F. Liang *et* A.R. Ferguson var. *deliciosa*) is a member of the family Actinidiaceae. It is a deciduous vine, usually growing on the edges of forests on the hills and mountains of southern and central China. Since it was introduced to New Zealand from China in 1904, kiwifruit plantings in New Zealand have increased rapidly, from 440 ha in 1970 to 16000 Ha in 1990 (Sale, 1991). In 1992 world production of kiwifruit was 793,000 tonnes with Italy and New Zealand each producing about 270,000 tonnes (Costa *et al.*, 1991). At present, New Zealand's share of the international kiwifruit market returns NZ$500 million per year.

'Hayward' is the only female cultivar commercially grown in New Zealand for export. Export markets prefer this cultivar due to its size, eating qualities and storage characteristics (Sale, 1991). A major aim in 'Hayward' kiwifruit production is to profitably obtain high yields of export quality fruit. Higher returns per tray are consistently obtained for large fruit.

Many aspects of kiwifruit vine management can strongly influence the profitability of a kiwifruit orchard. Some practices, such as fruit thinning (Cooper and Marshall, 1990 b), irrigation (McAneney *et al.*, 1991), and pollination (Hopping, 1990) to control fruit size

have been well documented. The impact of other standard practices are not fully understood, for example, the importance of rootstock and scion in vine performance. For many years seedlings of 'Bruno' have been the most widely used rootstocks for kiwifruit in this country because of the claimed high and uniform germination and strong vigour of this cultivar (Lawes, 1990). Field observations have indicated large variation in performance (for example, in fruit yield and/or fruit size) between vines with an apparently identical micro-climate (Lawes *et al*, 1986). It seems likely those differences are influenced by the seedling rootstocks, 'Hayward' scions, and/or the interaction between the two (Woolley *et al.*, 1988). There are few published reports of rootstock effects in kiwifruit (Cruz-Castillo *et al.*, 1991 a, b). No published comparisons of 'Hayward' scion selections or rootstock and 'Hayward' scion interaction effects are available.

Kiwifruit growers in New Zealand are sometimes reluctant to use cutting-grown plants, either as fruiting plants or as rootstocks, as many consider that a seedling rootstock gives rise to a vine which grows more rapidly and is both stronger and more productive. However, there is no clear evidence that kiwifruit cutting-grown plants on their own roots are inferior in the orchard (Lawes, 1990).

Root systems can also influence the postharvest quality and storage potential of fruit commodities. In grapefruit and orange (Wutscher, 1979) rootstocks have increased the total soluble solids of the fruit after harvest. In apple, fruit maturity at harvest was advanced (Yadava and Doud, 1989), and fruit firmness after storage increased (Autio, 1991) with the use of specific rootstocks. In New

Zealand, there is considerable interest in identifying factors most responsible for influencing kiwifruit losses in storage (Hopkirk and Clark, 1992). However, little attention has been given to root system effects on postharvest quality and storage potential of kiwifruit.

While the rootstock-scion combination may influence vine growth, precocity, fruit size, and fruit storage, there are other factors that could affect crop characteristics. For example, fruit size may be affected by seed number, ovary size at anthesis, production of photoassimilates from the leaves, and the application of growth regulators.

Fruit growth is highly dependent on the seed number (Hopping, 1976). It has been demonstrated that seeds are a source of plant growth regulators (Moore, 1989). Large variations in the relationship between fruit size and seed number indicate that other factors may be important in fruit sizing. For instance pre-anthesis factors such as ovary size at anthesis may significantly influence the final fruit size. In peach (Scorza *et al.*, 1991), apricot (Jackson and Coombe, 1966), and also kiwifruit (Lai, 1987) fruit from early opening flowers are larger at harvest than those from late blooms. In strawberry (Cheng and Breen, 1992) cell number at anthesis was important for achieving superior fruit growth.

Crop yield depends on an adequate production of photoassimilate by the leaves (Lai, 1987). Regions of assimilate accumulation are known as sinks (see Chapter 4). The strength of the various carbon sinks within the vine can be investigated by defoliation studies but little is known about the carbohydrate costs of

supporting growth of the different organs after a partial kiwifruit vine defoliation.

The use of exogenous plant growth regulators for experimentally increasing fruit size has been used in many tree fruit species. Hopping (1976) applied a range of hormones to kiwifruit, but obtained only a small increase in fruit size. Okamoto *et al.* (1981), called attention to the fact that certain substituted phenylureas were very effective cytokinins. Iwahori *et al.* (1988), and Ogata *et al.* (1989), showed that the synthetic cytokinin substance CPPU (N-(2-chloro-4-pyridyl)-N-phenylurea) increased the size of kiwifruit, and similar effects were described by Lawes and Woolley (1990) in New Zealand.

Three related areas of kiwifruit physiology where investigated in this thesis. 1. The contribution of the scion, the rootstock, and the interaction between the two on field performance of 'Hayward' vines four, five, and six years after propagation were investigated. Multivariate statistical techniques such as multivariate analysis of variance, and canonical variate analysis were used to characterise such effects. This project was carried out from 1988-91 with vines at the Fruit Crops Unit, Massey University.

This study also presents data on fruit quality (total soluble solids and fruit firmness) at harvest and after storage for different 'Hayward' selections both own rooted, and topworked on selected clonal kiwifruit rootstocks.

2. The effect of flowering date within kiwifruit vines on the ovary and final fruit size was evaluated during three seasons. The consequences of a partial defoliation on fruit sizing, vegetative growth and bloom return, and seasonal content of vine carbohydrates were also evaluated.

3. Five aspects of the application of growth regulators were investigated: a) The effect of different plant growth regulator combinations on the fruit of 'Hayward' and 'Kramer Hayward' kiwifruit; b) The effect of a hormone mixture on the growth of different tissues in a kiwifruit; c) The uptake, distribution and harvest residues of $^{14}$C-CPPU in 'Hayward' fruit; d) the effects of seeds and growth regulators on the growth of kiwifruit; and e) The fruit size response to CPPU of fruit from early and late flowers.