Quote: The cross-fertilization of ideas across the worldwide growing community has . . . led to some interesting and successful hybrid systems.

High Density Orchards: An Option for New Zealand?

John W. Palmer
HortResearch
Nelson Research Center, Motueka, New Zealand

Presented at the 42nd Annual IDFTA Conference, February 20-24, 1999, Hamilton, Ontario, Canada.

INTRODUCTION

For many years the New Zealand apple industry has relied upon production from the intermediate vigor rootstocks MM.106 and M.793 with trees planted at 5 x 3 m, 666 trees/ha (16.4 x 9.8 ft, 270 trees/acre). These orchards have produced some of the highest recorded yields in the world, e.g., Warrington (1994) quoted a yield of 163 t/ha (71 ton/acre) from a mature orchard of Granny Smith. Although the planting density has not changed greatly in New Zealand over the last 30 years, there has been considerable improvement in yield and fruit quality with the change from multi-leader trees to center leader trees and thence to slender pyramid training (Tustin et al., 1990). At the same time the New Zealand industry has been one of the world leaders in the rapid introduction of new cultivars, e.g., New Zealand production of Granny Smith and Red Delicious has fallen dramatically since 1988 and been replaced by Royal Gala and Braeburn. These changes to cultivar mix and production methods have undoubtedly improved the economic well-being of the fruit industry. New Zealand's production, however, is dominated by the export market and therefore is very sensitive to the increase in the world apple supply generally and specifically to alternative suppliers of cultivars such as Royal Gala, Braeburn and Fuji. In light of the long distance to the consumer markets for New Zealand's products, economic viability can be maintained only by continuing to hold a position in the market for premium rather than commodity produce. This will be achieved by 1) the rapid introduction of new cultivars, 2) further improvements to fruit quality and 3) reductions in the costs of production. This paper examines the possible role of more intensive planting systems on dwarfing stocks assisting the New Zealand fruit industry toward these ends.

DRIVERS FOR HDP

Elsewhere in the world, there has been widespread uptake of intensive plantings on dwarfing rootstocks, particularly in NW Europe and more recently in North America. The adoption of these systems has been in response to economic pressures for improvements to fruit quality, the rapid introduction of new cultivars, reduced production costs and reduced spray drift. Before any widespread adoption of intensive planting systems occurs within an area, however, a number of key drivers need to be in place.

A Demonstrated Advantage over Existing Methods

Growers in general tend to be somewhat skeptical of results from elsewhere in the world or from research plots in their own country being directly applicable to their own situation. It is, therefore, the innovators within each industry who lead the way, aided and abetted, by the scientists and extension services.

Availability of Dwarfing Rootstocks

The availability of newer rootstocks can be delayed by quarantine regulations or a nursery industry that lacks a vision of what rootstocks will be required in the future.

Economic Pressures

There is undoubtedly a reluctance on the part of growers to make wholesale changes to their existing systems of production if there is little perceived economic incentive to do so. Unfortunately, like the story of the frog in the pot of water, the heat can gradually increase until it is too late. Pipfruit growing is both a long-term and risky business so the grower must be studying current changes both in his/her own backyard and elsewhere if the business is to remain viable.

New Cultivars

Part of that study involves the selection of new cultivars that will give improved returns over his existing mix. Growers must consider not just the profitability of their existing orchards but whether that profitability could be enhanced by replanting with new cultivars. The high price per kilo for new cultivars has acted as a strong catalyst for intensive systems on dwarfing rootstocks in many parts of the world.

Skill Base

Finally there must be a sufficient understanding of a new system before it can be taken up successfully. The ready availability of cheap air travel undoubtedly has helped the movement of growers and advisors and in turn hastened the uptake of new systems. It is much easier to understand a system by standing next to a good example of it with a disciple of the system explaining the details rather than reading a third party's interpretation. The cross-fertilization of ideas across the worldwide growing community has also undoubtedly led to some interesting and successful hybrid systems.

THE NEW ZEALAND SITUATION

In contrast to Europe and North America, the New Zealand industry has been slow to adopt intensive plantings on dwarfing rootstocks despite the current economic pressures of the need for a rapid introduction of new cultivars, an improvement in fruit quality and a reduction in production costs, pressures which seem to be common to growers throughout the world. There are a number of reasons for this reluctance—in some cases the key drivers are missing or poorly developed—but there are some reasons specific to the southern hemisphere environment.

High Current Yields by Semi-intensive Systems

Reference already has been made to the very high yields obtainable in New Zealand by systems based on intermediate vigor rootstocks. It is unlikely that single row intensive systems on M.9 could match these high total yields; their advantage will undoubtedly be in the improved fruit quality and reduced production costs. It is important to note, however, that the 163 t/ha recorded for Granny Smith was with a cultivar that had no color requirement. Secondly, although multiple picks do increase the yield of fruit with acceptable color, the internal quality of later picks from large trees may not be adequate for market requirements in the future.

Lack of Dwarfing Rootstocks in Quantity

Although dwarfing rootstocks such as M.9 were imported into New Zealand many years ago, these were the virus-infected material. It is only within the last 10 years that virus-free material of M.9 and Mark has been available. Mark was the first virus-free dwarfing stock available in New Zealand and, although some growers have had excellent results from intensive systems on Mark, others have found its habits of overcropping, lack of growth and variability disappointing. More recent dwarfing rootstock introductions have included CG.202, 210 and 179. At present, nurserymen in New Zealand are not able to supply the requirement for trees on dwarfing stocks.

General Poor Quality of Nursery Tree

Precocity of intensive systems is not only one of the design criteria, it is also essential to offset the establishment costs. Precocity undoubtedly can be improved by planting well-feathered trees. Unfortunately nurserymen in New Zealand have yet to consistently produce large, well-feathered trees on dwarfing stocks.

Concerns over Woolly Apple Aphid

It is easy to forget that one of the main reasons for the breeding of the Merton and Malling-Merton series of rootstocks was to produce woolly apple aphid resistant rootstocks for the southern hemisphere producers in the British Empire. Woolly apple aphid infestation of the root systems of apples caused serious damage in the early part of the century. This was eliminated by the arrival of the resistant rootstocks. Unfortunately none of the widely available dwarfing apple rootstocks are resistant to woolly apple aphid so there always has been a concern that susceptible rootstocks will suffer badly from this pest. Although the parasite *Aphelinus mali* was introduced in the 1930s and is now widely distributed, it parasitizes aphids only on the aerial part of the tree.

Concerns over Sunburn

Undoubtedly one of the advantages of intensive systems is that the fruit is better exposed to the light with the attendant improvements to fruit quality. In a high solar radiation environment this may increase sunburn and so the system may fail to produce the desired fruit quality improvement.

Lack of Experience

There remains in New Zealand a lack of widespread experience and management skills with intensive systems.

When I arrived in New Zealand in early 1991, I felt strongly there was no overriding reason why intensive systems would not succeed in New Zealand as they have elsewhere. Dr. Stuart Tustin at Havelock North had already established a number of systems comparisons of Fuji on MM.106, M.26 and Mark in a number of sites. Consequently I concentrated on a system I knew well from Europe, the slender spindle on virus-free M.9. However, with the move toward less chemical inputs in orchards, I felt that multi-row systems would not be a long-term option, as such systems depended upon chemical weed control. I was fortunate to arrive just at the time when virus-free M.9 was becoming available. The clone of M.9 we use most widely in New Zealand at present was originally introduced from East Malling in the 1930s and heat treated in the mid ’80s. It is sometimes designated NZ9 to distinguish it from some of the other European clones that have been more recently introduced, e.g., T337, EMLA9, Pajam 1 and 2. Back in 1991, there was very limited interest in trees on dwarfing rootstocks. Over the last 8 years, however, there has been a gradual change and there is now a strong move toward smaller trees by 1) reducing the height of trees on MM.106 and M.793, 2) the use of M.9 interstem trees on MM.106 and M.793 and 3) the use of dwarfing rootstocks such as M.26, Mark and M.9. In 1991 only 5% of trees raised by a major nurseryman were on dwarfing rootstocks and interstems compared to 60% in 1998.

EXPERIMENTAL RESULTS

In 1991 there was very little experience in New Zealand with virus-free M.9, therefore it was important that we gain experience of its vigor to know what tree densities were feasible. I was fortunate to secure the cooperation of two Nelson growers who planted blocks of Royal Gala on NZ9 in the spring of 1993. Both growers were keen for some trial work to be done on their orchards and therefore a within-row spacing trial was established at each site. These trials then supplemented within-row spacing trials of Royal Gala, Fuji and Braeburn on M.9 that were planted at the same time on the Nelson Research Orchard. In the following year another spacing trial of Royal Gala, Fiesta and Fuji was planted in the Marlborough region. The majority of the results presented in this paper are from the two spacing trials on the Nelson grower orchards. Some of the early results from this work were presented by Palmer and Adams (1997).

On both Nelson grower sites unfeathered whips of Royal Gala/M.9, clone Galaxy, were planted in the spring of 1993 at five within-row spacings in a randomized block experiment with 5 blocks and 3 trees per plot separated by a single guard tree. On the first grower property, on a deep clay soil, the trees were planted with a row spacing of 3.5 m (11.5 ft) and within-row spacings of 0.75, 1.0, 1.25, 1.5 and 1.75 m (2.5, 3.3, 4.1, 4.9 and 5.7 ft), giving a range in tree densities from 3810 to 1633 trees/ha (1542 to 661 trees/acre). On the second orchard, on a fertile light silt soil, the trees were planted with a row spacing of 3.7 m (12.1 ft) and within-row spacings of 0.9, 1.15, 1.4, 1.65 and 1.9 m (3.0, 3.8, 4.6, 5.4 and 6.2 ft), giving a range in tree densities from 3003 to 1422 trees/ha (1215 to 575 trees/acre). Records included total number and weight of fruit per plot and trunk cross-sectional area (TCA). The trees were pruned as slender spindles by the researchers while the growers were responsible for the other cultural operations.

Tree growth, as indicated by TCA, was largely unaffected by tree density after the first growing season (Figure 1). Over the next 3 years tree density showed a more pronounced effect on TCA, with the suppression of growth becoming more severe with time at the higher tree densities. Yield per hectare showed a mirror image of the effects on growth (Figure 2), although curves have been fitted through the data as yield would be zero at a tree density of zero. As the yields were similar on both sites, the curves have been fitted through both data sets. There was no effect of spacing on yield per tree in the first cropping year (second leaf), with an average yield per tree of 3.5 kg (7.7 lb), so yield per hectare was a linear function of tree density. This is a frequent finding with trials of this type. The relationship between yield and tree density became more curvilinear from year 3 to year 5, with an increasing reduction of yield per tree at the closer spacings compared to the wider spacings, so that by the fifth leaf yield per hectare showed only a relatively small increase beyond 2500 trees/ha (1012 trees/acre). Trees at 2200 trees/ha (890 trees/acre) reached yields of 80 t/ha (36 ton/acre) by year 5. These results illustrate how rapidly new cultivars could be brought on stream using such planting systems. The average yield per tree and mean fruit weight from all spacings for each year are given in Table 1. Fruit quality generally was very good although no details of defects were collected. Mean fruit weight was large, above 180 g in all cases except for Grower 2 in year 4 when there was a misunderstanding over the hand thinning and the trees were thinned very late. Other than the effect of spacing on growth and yield per tree, spacing effects to date have been small. Closer spacings resulted in a significant decline in mean fruit weight in years 3 and 4 for Grower 1 and year 4 for Grower 2 but not in other years. There has been no significant effect of spacing on the fraction of fruit removed in the first pick.

The use of well-feathered trees at planting would have further improved precocity and probably saved almost a year in the cumulative cropping cycle. Work with unfeathered and feathered trees on M.9 in New Zealand has shown that yields in the first 2 or 3 years can be increased by two to threefold by using feathered trees (Palmer and Adams, 1997).

Royal Gala does not normally suffer serious problems of russet or sunburn and therefore is perhaps an "easy" cultivar to try on M.9. In our other trials of Braeburn and Fuji on M.9 we have seen serious downgrading of Fuji due to russet, particularly in the Nelson region. In drier regions such as Marlborough, we have not seen such serious problems of russet on M.9. Sunburn levels on Fuji and Braeburn on M.9 reached 12% and 9% in Nelson in the bad sunburn year of 1997/98. This is somewhat higher than growers experienced on larger trees, although this was counterbalanced by good color and high soluble solids.

Although results have been very encouraging from these trials on M.9, it is appropriate to consider the issue of woolly apple aphid. At present we have no commercially available dwarfing apple rootstocks resistant to woolly apple aphid. No serious woolly apple aphid problems have been seen in these orchards to date, although none of these orchards are under IFP. Certainly woolly apple aphid seems generally to be a more common pest under IFP than under conventionally sprayed systems but the parasite *Aphelinus mali* can successfully control this pest once established under IFP. Although M.9 interstem trees on MM.106 or M.793 offer an insurance policy against woolly apple aphid root infestation, tree size to date from our interstem trials is more in the M.26 size range or slightly larger. The economic advantages of the intensive systems on M.9 rootstock may, however, outweigh the risk of serious woolly apple aphid debilitation for growers wanting to move to intensive plantings in the immediate future. In the longer term, dwarfing rootstocks with woolly apple aphid resistance will remove this concern.

Further work is in progress to examine in detail fruit quality from the trials described here and from an experiment comparing Royal Gala planted intensively on M.9 and at the more conventional spacings on MM.106.

SUMMARY

Intensive apple orchards on M.9 have shown good precocity, high yields and excellent fruit size. These systems offer the New Zealand pipfruit growers new management options for their future orchards as they seek to respond to the ever-changing economic and market pressures on the pipfruit business. In my 8 years in New Zealand there has been a positive shift in the attitude of growers to smaller trees and undoubtedly this will accelerate as dwarfing rootstocks resistant to woolly apple aphid become widely available.

ACKNOWLEDGEMENTS

These trials could not have been done without the helpful support of the growers concerned. It is no mean task in a hectic picking season to ensure that the trial plots are looked after. Further thanks are extended to ENZA for funding some of the work referred to in this article.

LITERATURE CITED

Palmer, J.W. and H.M. Adams. 1997. Early results with intensive systems of apples on virus-free M.9 rootstock in New Zealand. Acta Hort. 451:487-493.

Tustin, D.S., P.M. Hirst, W.M. Cashmore, I.J. Warrington and C.J. Stanley. 1990. The principles and practices of training slender pyramid trees for high intensity production. Compact Fruit Tree 23:83-92.

Warrington, I.J. 1994. The 'Granny Smith' apple. Fruit Var. J. 48:70-73.

Table 1. Mean yield per tree and average fruit weight of Royal Gala/M.9 over four seasons at two grower orchards in Nelson, New Zealand.

	Grower 1		Grower 2	
Year	Yield (kg)	Mean wt. (g)	Yield (kg)	Mean wt. (g)
2	4	198	3	208
3	13	191	16	180
4	21	185	26	147
5	34	180	38	189

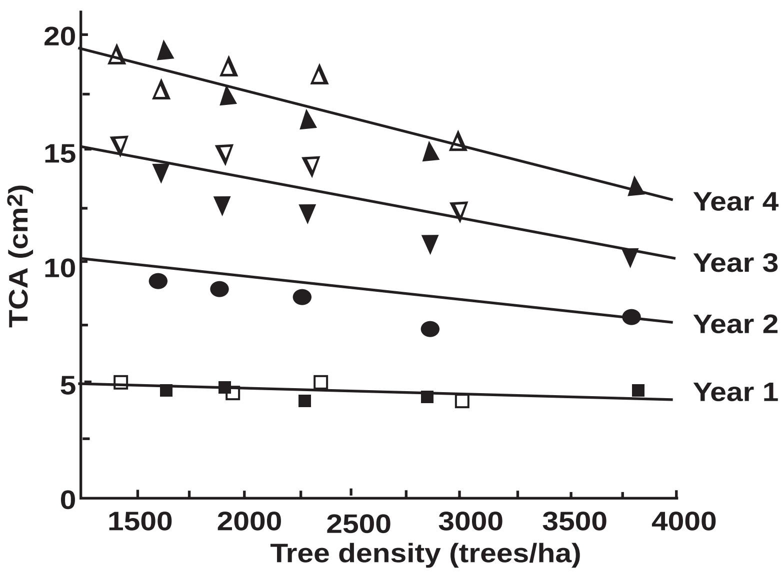

Figure 1. Growth of TCA of Royal Gala/M.9 trees over four growing seasons (first to fourth leaf) from two sites (closed symbols grower 1, open symbols grower 2) in Nelson, New Zealand.

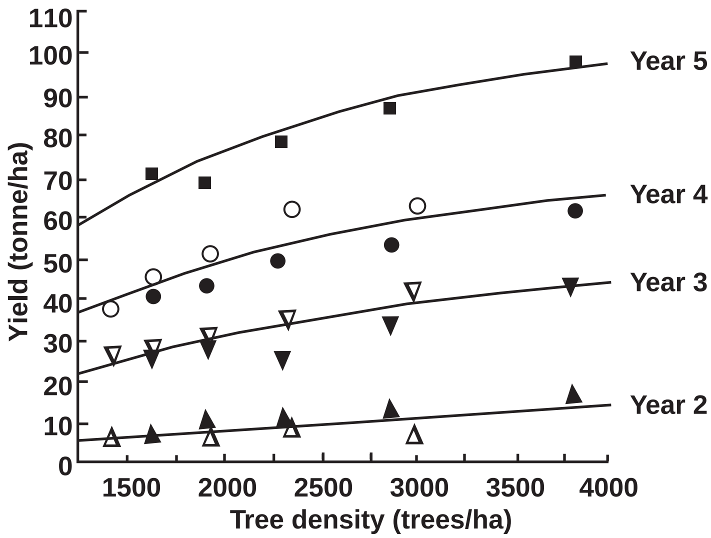

Figure 2. Annual yield of Royal Gala/M.9 trees over four cropping years (second to fifth leaf) from two sites (closed symbols grower 1, open symbols grower 2) in Nelson, New Zealand.