The Evolution of Central Leader Apple Tree Management in New Zealand

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Presented at the 43rd Annual IDFTA Conference, February 6-9, 2000, Napier, New Zealand.

A snapshot of the New Zealand apple industry in the early 1960s shows an industry very similar to many other international apple regions in production capability and efficiency. Orchards were planted on vigorous rootstocks (Northern Spy, M.12, M.16) which required wide tree spacing, typically 6 x 6 m (19.6 x 19.6 ft). These rootstocks did not encourage precocious cropping, requiring 7 to 10 years to achieve significant production. Orchards were developed by training trees as vase-shaped multi-leaders, encouraging extensive tree spread to fill the available space. Trees were very large, often reaching 6 m (19.6 ft) height at maturity.

THE MCKENZIE CENTRAL LEADER

From the late 1950s a strong research effort to evaluate the new Merton and Malling-Merton series rootstocks was led by Dr. Don McKenzie who had recently returned to Hawke's Bay from graduate studies in rootstock physiology at East Malling Research Station in the UK. Dr. McKenzie had wide exposure to new ideas in orchard systems for apple while in the UK including the early directions toward dwarf trees and intensification of planting systems. He was also closely attuned to innovations occurring in North America.

He developed his ideas on appropriate tree form and dimensions through calculations of space utilization and studies of crop distribution and shading characteristics among various tree training forms. He confirmed that a pyramidal tree shape provided the most productive and efficient form for enhancing orchard productivity. The central leader concept for tree design was thus adopted into orchard systems development in New Zealand.

Meanwhile, the precocity, tree size control and productive potential of MM.106 rootstock emerged among results from his rootstock trials conducted in the rich soils and benevolent climate of Hawke's Bay. Here was a "semi-dwarfing" rootstock which offered apple growers many of the attributes that were necessary to lift apple orchard productivity onto a higher plane.

Dr. McKenzie's earliest central leader trees were similar to North American examples with branching arranged as a spiral whorl up the central trunk of the tree. This tree form demonstrated very good productivity even when excessive branching caused shading. To overcome shading he developed the concept of forming tiers of four branches flattened to 30˚ above horizontal separated by wide spaces of up to 1 m (3.3 ft) to encourage light penetration. The four branches in each tier were arranged in a cruciform array with a branch in each direction along the row and perpendicular across the row. Along each branch, fruiting laterals were trained in a herringbone pattern to be the main source of fruiting wood.

Very structured tree training from the outset was used to establish McKenzie central leader trees. Heading of trees was used to stimulate vigorous growth at planting. Only the central leader and the four branches needed for the basal tier were retained in the second year. Wires and ties were used to train the tier branches into their cruciform position and correct angles and encouraged to grow. The central leader may have been headed again at the height where the second tier was required about 1 m (3.3 ft) above the basal tier. The training was very intrusive and invigorating by today's standards but not so in the 1960s.

The New Zealand apple industry is firmly on track toward the widespread adoption of dwarf tree intensive planting systems.

To maintain cropping potential from healthy fruit buds in good light environment, McKenzie introduced the concepts of renewal pruning to New Zealand apple tree management. This was also necessary to overcome invigoration from traditional pruning and ensuring adequate fruiting wood to furnish the high cropping potential of the tree on MM.106 rootstock.

The McKenzie central leader semi-intensive orchard system reduced tree size to 4.2 to 4.5 m (13.8 to 14.8 ft) in height and intensified planting densities from 270 to 580 trees per hectare (109 to 235 trees/acre) through the benefits of the semi-dwarfing MM.106 rootstock. Many of the features of the system had practical ideas behind them. The tiers facilitated better light distribution. The cruciform branch array allowed easy access for workers and spray penetration into the tree. The strong branch structure was thought necessary for the trees to carry the heavy crops possible while remaining unsupported.

With benefit of hindsight the development of McKenzie central leader system appears a logical early development in central leader planting systems. But in its day the ideas were utterly revolutionary. Almost every concept was new or contrary to existing orchard experience and practice. Early adoption was difficult. McKenzie's innovations in orchard systems were matched by his energy in technology transfer. He provided extensive information support for his new concepts and even planted an orchard of his own to demonstrate the principles at work. He talked of the concept of the "three legged stool"—the three components that made the central leader management system work: precocious semi-dwarfing rootstock, tree training and renewal pruning.

By 1970 in a new era of expansion of apple plantings, innovative growers moved strongly into adoption of the McKenzie central leader planting system. The 1970s became the decade of the McKenzie central leader planting system as the apple industry underwent expansion and changes in varieties. From this time the New Zealand apple industry grasped innovation and a culture of change and differentiation after some severe market downturns in the 1970s. An industry shift toward new cultivars began with Gala, followed later by Braeburn and Royal Gala.

THE DRIVE TO IMPROVE ORCHARD PRECOCITY

By early 1980s, fruit growers were looking for improved efficiency and precocity from new orchards because of the high market value of new cultivars and the high cost of borrowing capital. With a shift to improved virus-free planting stock, excessive vigor had become a problem with the McKenzie central leader management and tree size had increased as a result. Despite their original design, many mature McKenzie central leader trees had excessive shading and diminishing fruit size and quality. More rapid onset of cropping by new plantings was needed than was achieved by the prescriptive McKenzie training methods.

A team of young well-educated fruit advisors in the Ministry of Agriculture advisory service were actively exploring new European ideas for central leader tree management. Lespinasse's vertical axis system particularly appealed to the New Zealanders with its less intrusive central leader management and better use of rootstock precocity and cultivar growth habit to improve orchard performance and reduce tree vigor. They were accustomed to renewal pruning and quickly adopted the techniques for rapid canopy development through using the natural growth tendencies of the tree and reduced pruning. The vertical axis seemed an ideal approach to improve young tree yields, accelerate orchard productivity and obtain better vigor control.

The pioneers at the forefront of this second revolution in central leader apple tree management included people like Ian Ivey, Peter Ellis, Richard Hill, Roy McCormick and John Dine, most of whom are still active in the New Zealand apple industry. These innovative advisors were supported and mentored by John Wilton, MAF pome fruit specialist based in Auckland.

Widescale expansion of new apple planting occurred from the early 1980s as the industry moved into Braeburn, Royal Gala and Fuji. Significant areas were planted at increasingly higher densities of 670 to 1250 trees per hectare (271 to 506 trees/acre), using MM.106 rootstock. Individual interpretations of vertical axis were applied with the most extreme approach recommending almost no tree training in the first 3 years. A common view was to "let the fruit train the tree." A combination of extremes of intensive planting and minimal canopy management resulted in some astonishing yields from 3- and 4-year-old plantings of Royal Gala. The wide variations of interpretation and performance of vertical axis also stimulated renewed effort in orchard systems research.

THE SLENDER PYRAMID TREE MANAGEMENT SYSTEM

Applying high density planting practices using intermediate vigor rootstocks created classical problems of planting systems—excessive crowding leading to shading as trees outgrew their allotted space with rapid fall-off in orchard performance. Strong opinions were debated on how to conduct vertical axis management.

Vertical axis tree management for French fruit growing needs meant that trees rapidly became column-shaped with the attendant problem of shaded lower canopy. New Zealand modification of the axis tree to ensure a well-developed basal tier in the tree was an outcome of the research effort in the 1980s.

The tree style was termed the slender pyramid because of its characteristic shape. Slender pyramid management was developed initially with systems using intermediate vigor rootstocks by adapting dwarf tree vertical axis management methods. This approach harnessed the high precocity expressed by MM.106 in the New Zealand climate.

Training a well-formed basal tier of branches in the slender pyramid tree meant that 650 to 900 trees per hectare (263 to 364 trees/acre) were appropriate densities for MM.106 rootstock vigor. But minimal pruning and maintaining additional basal canopy branches in young trees maximized canopy development and precocious fruiting early in the orchard life. Yet on reaching full canopy size, trees were not excessively crowded.

Vertical axis young tree management techniques were used to manage the canopy development of slender pyramid trees. Early summer removal of the unwanted lateral shoots and removal of shoot competition with the major growing points accelerated tree development and early fruiting. These techniques also reduced the need for winter pruning in young trees, helping establish lower vigor growth with time.

At maturity slender pyramid orchards have a characteristic saw-tooth profile along the orchard row with slim upper canopies separated by light wells which extend down toward the basal tier. Our research has shown this architectural feature is very important for ensuring good light distribution into the lower inner tree canopy.

From the mid-1980s most new apple orchard plantings were trained as versions of vertical axis or slender pyramid central leader management. Apple orchard precocity was greatly enhanced compared with McKenzie central leader and the best plantings produced comparably with Northern Hemisphere dwarf tree intensive planting systems. This performance is one reason why the interest in dwarf tree intensive planting systems has developed more slowly in New Zealand compared with other world apple production regions. Indeed the vertical axis-slender pyramid approach intensified production systems in New Zealand in a way unlike elsewhere in the world but achieved a similar outcome. In New Zealand, the performance of MM.106 was enhanced by changing tree management to maximize the expression of precocity and vigor reduction through early cropping. While planting densities were increased in response to the new tree training methods, practical limits meant highest densities were 1000 trees per hectare (405 trees/acre), with the optimum around 750 to 900 trees per hectare (304 to 364 trees/acre).

THE MOVE TOWARD DWARF ROOTSTOCKS AND HIGH DENSITY PLANTING SYSTEMS

In the mid 1980s, a few very innovative fruit growers were following international trends in intensive systems based on dwarf rootstocks M.26 and M.9. Mark rootstock from USA was commercialized under license in New Zealand at this time and virus-free M.9 was released to industry after heat treatment virus elimination. M.26 rootstock was increasingly available. The issue of susceptibility of dwarf rootstocks to woolly apple aphid *(Eriosoma lanigerum)* had long been an industry concern and a constraint to their adoption.

With the ongoing necessity to increase apple orchard efficiency, development of intensive planting systems using dwarfing rootstocks seemed a logical direction for the New Zealand apple industry. Research plots were established in 1988 after delays in supply of dwarf rootstocks. Commercialization of Mark meant that both research and industry were more or less forced to commence the New Zealand high density planting (HDP) experience using this rootstock. The initial research approach was to compare planting systems of appropriate densities on MM.106, M.26 and Mark rootstocks using slender pyramid tree management. At the same time the first commercial trial plantings were established by growers from the late 1980s. The original few growers chose systems using M.26 or Mark.

Supplies of virus-free M.9 were extremely limited and virtually no M.9 was commercially available. By 1990, dwarf tree intensive planting systems research was expanding with studies to compare slender pyramid management with slender spindle management at densities up to 2000 trees per hectare (809 trees/acre) but still dependent on Mark rootstock.

In 1991, Dr. John Palmer accepted a research position in New Zealand after 20 years' experience at East Malling Research Station in the UK. John was a specialist in high density orchard planting systems based on M.9 dwarfing rootstock and slender spindle management. He expanded the New Zealand research in dwarf central leader planting systems with a focused effort on performance of planting systems using M.9. Rootstock availability was improving and researchers were keen to move beyond Mark rootstock.

Dr. Palmer developed an integrated program applying his extensive experience from East Malling. Phase one was to work with the nursery industry to improve tree quality and obtain large branched trees for planting. Without ideal tree quality initially, classic single row slender spindle intensive planting systems studies were established using planting densities from 1,100 to 3,800 trees per hectare (445 to 1538 trees/acre). Strong industry linkage was a feature in this research with half of the trials located on properties of growers undertaking early commercial trial plantings of M.9 HDP systems. This early work with M.9 slender spindle systems soon began to demonstrate the anticipated rapid cumulative yield and fruit quality attributes from M.9 dwarf tree intensive systems

Throughout the 1990s the groundswell of interest in intensive planting systems has grown. There is a strong research base of intensive central leader planting systems research and rootstock evaluation to find new dwarfing rootstocks with disease and pest resistances. Dwarf tree management philosophy varies among growers and researchers alike. In our earliest comparisons we have found that productivity was most related to planting density and little difference was found between slender pyramid and slender spindle training systems over a 6-year study of Southern Snap on Mark rootstock. However many growerøs manage intensive systems using a vertical axis-slender pyramid style of tree management in preference to classic slender spindle. Tree height quickly reaches 3.5 m (11.5 ft) which provides very rapid canopy development, outstanding productivity from a young age and control of vigor. More than anything growers are learning the value and importance of large high quality trees as orchard planting stock.

As we begin the new century, the New Zealand apple industry is firmly on track toward the widespread adoption of dwarf tree intensive planting systems using single row systems. Tree form will be some version of central leader management influenced by the objectives of the fruit grower. Some highly successful pedestrian orchards have been developed although most growers presently appear to prefer slightly taller trees for the ease of training, vigor control and additional productivity achievable when trees mature. The greatest constraints to more rapid adoption of intensive systems are a shortage of the dwarf and semi-dwarf rootstocks and the lack of profitability in apple production to fund widespread re-development.

COMPACT FRUIT TREE

Quarterly Journal of the International Dwarf Fruit Tree Association

Volume 33, No. 3, July 2000

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Compact Fruit Tree, the quarterly journal of the International Dwarf Fruit Tree Association (IDFTA), is devoted to the publication of technical information for growers of deciduous tree fruits. It is published in January, April, July and October by IDFTA (Charles Ax, Business Office, 14 S. Main Street, Middleburg, PA 17842 USA; Phone 570-837-1551; Fax 570-837-0090). To receive four issues per year of *Compact Fruit Tree*, payment of the IDFTA membership fee of $80 per year should be sent to the above address and made payable in US dollars to IDFTA.

Manuscripts and editorial comments should be sent to Editor, *Compact Fruit Tree*, 1100 N. Western Avenue, Wenatchee, WA 98801 (Phone: 509-663-8181, ext. 233; Fax: 509-662-8714; E-mail: etaplz@wsu.edu). All articles presented at the annual conference of the IDFTA are published in *Compact Fruit Tree*. Submission of additional manuscripts is encouraged.

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Compact Fruit Tree is produced for IDFTA by the staff of *Good Fruit Grower* magazine, Yakima, WA.

Design & Layout by:

GOOD FRUIT GROWER MAGAZINE

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