

Future Orchard 2012 – Huon, Tasmania

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Intensive Apple Growing Systems

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Technical Summary

Some key elements of the industries competitiveness on world markets are dependent on intensive growing systems which can deliver early, high and sustainable production of high quality fruit. A benchmarking study conducted by the apple industry concluded that Australia lags behind its main competitors in terms of orchard productivity and costs.

In September 2000 a demonstration orchard was planted at Grove Research Station, Huon Valley, Tasmania to assist growers in the planning, design and development of modern and efficient orchard systems.

The transfer of technology program has been carried out by Department of Primary Industries and Water, Tasmania in co-operation with Horticulture Australia and Tasmanian Apple Industry.

The mainstream commercial apple varieties Gala, Fuji, Pink Lady and Sundowner were chosen for their economic value and contrasting growth characteristics to provide a range of challenges in intensive hedgerow systems. The best available dwarfing stocks and interstems (M9, M26, M9/MM106, M9/MM102) and semi-dwarfing stocks (MM102 and MM106) are used across all cultivars to match the tree size requirements of five orchard densities 1904, 2857, 3333, 4444 and 6666 trees/ha. The planting is trained on a single row compact pyramid shape hedgerow supported by the standard vertical post and wire trellis. The system is fully compatible with integrated fruit production.

Orchard establishment costs - The cost of orchard establishment including the planting phase and the first season of orchard development ranged from \$33,884 to \$67,321 for 1904 to 6666 tree densities/ha. The main costs were nursery trees, site preparation, tree supports, irrigation and tree training.

It is extremely important that very high intensive orchard establishment inputs are matched with high early yields as demonstrated in this project.

Early production - In year two, many systems yielded in excess of 30 tonnes and some exceeded 40 tonnes per hectare. The highest crop 48.7 t/ha was recorded in Sundowner/MM106 feathered ("F") trees planted at 3.5 x 1.0m (2857 trees/ha).

The crop in year three reinforced the effect of dwarfing stocks and tree density on high and regular production in intensive orchards. Except for Fuji, yields mainly equalled or were higher than those produced in year two.

Productivity was particularly impressive in Gala, Pink Lady and Sundowner "F" type trees. Gala and Sundowner produced the best results on M9/MM106, M26 and M9 in all high densities (3333 – 6666 trees/ha) and on MM106 at 2857 trees/ha.

In Pink Lady all stocks and tree spacings produced good to excellent results.

The most impressive combinations were MM106 at 2857 and 1904 trees/ha, MM102 at 2857 and 3333 trees/ha and M9/MM106 and M26 at 3333 and 4444 trees/ha.

Cumulative crops for years two and three were 49 – 92.2 t/ha for Fuji, 42 – 86.6 t/ha for Gala, 49.3 – 93.1 t/ha for Sundowner and 63.1 – 106.9 t/ha for Pink Lady.

The project has clearly demonstrated that best practise new orchard technology – high tree densities (2500-3500 trees/ha), high nursery tree quality material (large size well branched trees), dwarfing rootstocks, minimal pruning and tree training, can deliver many important benefits to the apple industry.

The project should continue beyond the present phase to generate further information for the industry on orchard management, productivity, fruit quality and economic parameters.

Introduction

The 0.85 ha demonstration orchard was planted at Grove Research Station, Huon Valley Tasmania in September 2000. The transfer of technology project has successfully completed the first three seasons of orchard development. The program is being carried out by Department of Primary Industries, Water and Environment in co-operation with Tasmanian Apple Industry and Horticulture Australia.

Some key elements of the industries competitiveness on world markets are dependent on intensive growing systems which can deliver early, high and sustainable production of high quality fruit. A benchmarking study conducted by the apple industry concluded that Australia lags behind its main competitors in terms of orchard productivity and costs.

The main building blocks of intensive orchard design and establishment, variety/rootstock/tree spacing/tree arrangement/canopy shape/tree training/pruning and tree quality are incorporated in the project to ensure that the growers gain full appreciation of basic skills in modern orchard planning and development.

A number of effective tree management methods to improve early fruit production have been demonstrated to the industry.

The mainstream commercial apple varieties Gala, Fuji, Pink Lady and Sundowner were chosen for their economic value and contrasting growth characteristics to provide a range of challenges in intensive hedgerow systems. The best available dwarfing stocks and interstems (M9, M26,

M9/MM106, M9/MM102) and semi-dwarfing stocks (MM102 and MM106) are used across all cultivars to match the tree size requirements of five orchard densities 1904, 2857, 3333, 4444 and 6666 trees/ha. The planting is trained on a single row compact pyramid shape hedgerow supported by the standard vertical post and wire trellis. The system is fully compatible with integrated fruit production. It includes the latest pest and disease management strategies, monitoring, use of pheromones and targeted low impact sprays.

**Outline of predominant treatment –
Variety / rootstock / tree density combinations**

➤ Tree density/ha	1904	2857	3333	4444	6666
➤ Spacing (m)	3.5 x 1.5	3.5 x 1.0	3.0 x 1.0	3.0 x 0.75	3.0 x 0.5
➤ Variety/rootstock					
Gala)			M9	M9	M9
Fuji)	MM106	MM106	M9/MM10 6	M9/MM106	M9/MM106
Pink Lady)	MM102	MM102	M9/MM10 2	M9/MM102	M9/MM102
Sundowner)			M26	M26	M26

Tree Management

The first season's orchard canopy development was based on very minimal pruning, and no central leader shortening in order to encourage optimum tree development, an essential prerequisite for early fruit production. Some trees were "headed" at 1.1m to illustrate the effect of level of pruning on early cropping.

The nursery tree quality has a large impact on intensive orchard development and performance. In this project both well feathered and unfeathered (rods) one year old nursery trees were used for appropriate tree densities and are able to compare their performance during the early phase of orchard production.

In late October the trees planted as 'rods' were 'scored' with a 'V' blade at 1.1m above ground level to promote primary shoot development. This simple and inexpensive method produced excellent results. Ample number of sideshoots emerged in the right section below the scored point. Similar results are obtained by some proven tree branching methods used during the nursery phase of high quality tree production.

Other treatments (table 1) were demonstrated, and included bud notching (10-12 buds in the 0.7-1.1m zone) and Cytolin™ (15 mL/L) alone and in combination with scoring and bud notching. Bud notching produced similar results to scoring but was much more expensive (28c v 1.6c/tree). Cytolin™ was ineffective.

In late January new seasons' shoots were pruned off if located below 0.7m on the trunk or were in competition with the centre leader and out of balance with the rest of the compact-slender pyramid tree form.

The same exercise was repeated at the end of the first growing season. Very few shoots were removed (in line with minimal pruning principles). At the end of the dormant period all 'stronger'

primary laterals on the centre leader were tied down just below the horizontal position to reduce vigour and encourage fruitfulness. This was particularly important in "rod" type trees in very high densities and in more vigorous variety/rootstock combinations.

Light pruning was also practiced during the second and third year of orchard development based on shoot thinning and removal of narrow angle laterals along the centre leader. The pruning and training approach during the orchard development phase (year 1-3) created excellent fruiting canopy surface. This is well reflected in high fruit production levels in the second and third growing season.

Orchard Development and Production Costs – Year 1 and 2

The main input costs for orchard development at the end of the first year (land preparation, nursery trees, tree support, irrigation system and the first season of orchard management) have been calculated for all five tree densities 1904, 2857, 3333, 4444 and 6666 trees/ha (table 2 A & B). The respective costs per hectare are \$33 884, \$40 196, \$45 247, \$52 605 and \$67 321. The major costs are planting material, land preparation and tree support in that order.

Land preparation costs can vary to a large degree depending on the condition of the site. Considerable savings (\$4960) can be achieved if soil replant and orchard clearing do not have to be addressed.

In regard to nursery tree costs, the aim should be for moderately high planting density (2500-3500 trees/ha) using the best quality trees to create 'instant' fruiting canopies. Excessive tree numbers (over 3500/ha) will increase the establishment costs without delivering corresponding yield benefits.

Tree training (tying down primary shoots) and pruning (table 2C) were some of major manual input operations in the second season of orchard development. These costs (\$) per hectare ranged from 1095-3055; 403-3040; 1599-3242 and 2767-4481 for Fuji, Gala, Sundowner and Pink Lady respectively. The level of inputs was partly influenced by tree densities, degree of branching and tree vigour.

Hand thinning was also very labour intensive due to a cautious approach to chemical thinning of young trees. Gala, Fuji and Sundowner carried the heaviest fruit set. The cost (\$) amounted to 1340-3919 (Fuji), 749-3804 (Gala), 1715-4395 (Sundowner) and 864-2233 (Pink Lady).

Orchard Production Costs – Year 3

In the third season the fruit production costs (table 3) were dominated by excessive labour inputs in fruit thinning.

A very heavy fruit set and less aggressive spray thinning approach contributed to a very high labour cost associated with hand thinning.

Average costs (\$/ha) across all four varieties increased in line with tree densities 1815, 2257, 2601, 3064 and 3345 for 1904, 2857, 3333, 4444 and 6666 trees/ha respectively.

A similar pattern of costs emerged within each cultivar (table 3.1).

Gala and Sundowner were the most costly to hand thin particularly at high densities (4444 and 6666 trees/ha). Sundowner costs were the highest \$3979 (4444 trees/ha) and \$4144 (6666 trees/ha). Future pruning and spray thinning strategies will address the cost of this orchard operation.

In contrast to manual fruit thinning and other orchard operations, minimal pruning technique was very inexpensive (tables 3 and 3.2).

If allowances are made for future efficiencies in crop regulation, then for current crop levels, the total annual costs/ha prior to harvest (table 3) are not too excessive.

This can be seen in the following examples:

Gala / M26 “F” (feathers) at 3333 trees/ha produced 39.6 t or 99 (400 kg) bins/ha and the total year 3 costs were \$5409/ha which translates to \$51/400 kg bin.

Pink Lady / MM106 “F” at 2857 trees/ha produced 64.8 t (162 bins) against the total costs of \$4856 or \$29.97/400 kg bin.

Early Fruit Production in Year 2

In regard to total production per hectare in the second season (table 4), many orchard systems (variety/stock/tree density/tree quality combinations) in this project produced yields in excess of 30 tonnes and some exceeded 40 tonnes per hectare. The highest crop of 48.7 t/ha was recorded in Sundowner/MM106 “F” planted at 3.5 x 1.0m (2857 trees/ha).

These results clearly indicate that modern intensive planting systems can deliver very high commercial yields in the second year after planting.

As expected tree density and rootstock have a big impact on early production but other factors such as nursery tree size and tree shape (degree of branching) and level of pruning have a significant effect on the final orchard performance. This is clearly demonstrated in the project: Sundowner/MM106 planted at 3.5x1.0m (2857 trees/ha) produced the following results (table 5):

'Rod' (“R”) type trees cut back to 1.1m after planting - 24.3 t/ha (100%)
“R” type trees not pruned after planting - 35.8 t/ha (147%)
“F” type trees not pruned after planting - 48.7 t/ha (200%)

The level of pruning (tree heading at planting) although not too excessive (cut back to 1.1m), did have a dramatic effect on the first crop in year two.

Other examples in table 5 also indicate that the best practice approach, using feathered trees and no tree heading at planting, consistently delivers very large gains in early production compared with orchards based on rod type trees and "severe" pruning.

Early Fruit Production in year 3 and cumulative yield performance

The crop in year three (table 6) reinforced the effect of dwarfing stocks and tree density on high and regular production in intensive orchards. Except for Fuji, in most instances yields were equal to or higher than those produced in year two.

Productivity was particularly high for Gala, Pink Lady and Sundowner “F” type trees.

Some “F” type trees still maintained yield advantage over “R” type but the difference was less pronounced compared with the second season.

Gala and Sundowner produced the best results on M9/MM106, M26 and M9 in all high densities (3333 - 6666 trees/ha) and on MM106 at 2857 trees/ha.

In Pink Lady all stocks and tree spacings delivered good to excellent results.

The most impressive combinations were MM106 at 2857 and 1904 trees/ha, MM102 at 2857 and 3333 trees/ha and M9/MM106 and M26 at 3333 and 4444 trees/ha.

Cumulative yields for years two and three (table 7) were 49 - 92.2 t/ha for Fuji, 42 - 86.6 t/ha for Gala, 49.3 - 93.1 t/ha for Sundowner and 63.1 – 106.9 t/ha for Pink Lady.

Most of the stock/density combinations produced impressive yields. In general, high tree densities on dwarfing stocks M9/MM106, M26 and M9 produced high crop volumes.

The highest yields were achieved with Fuji 92.2 t/ha on M9/MM106 (3.0 x 0.5m), Gala 88.6 t/ha on M9 (3.0 x 0.5m), Sundowner 93.1 t/ha on M9/MM106 (3.0 x 0.5m) and Pink Lady 106.9 t/ha on MM106 (3.5 x 1.0 m).

With minor exceptions for Gala, Sundowner and Pink Lady “F” type trees performed better than “R” type.

In relative terms good “F” type trees produced excellent results at lower densities compared with “R” type planted at much closer in row spacings. This is illustrated by Gala/M9/MM106 (3.0 x 1.0m) and on MM106 (3.5 x 1.0m), Sundowner/M9/MM106, M26 (3.0 x 1.0m) and MM106 (3.5 x 1.0m) and Pink Lady/M9/MM106, M26, MM102 (3.0 x 1.0m) and MM106 (3.5 x 1 and 3.5 x 1.5m).

With good nursery tree quality “F” at 2857 and 3333 trees/ha can produce excellent results compared with quality “R” at 4444 and 6666 trees/ha.

Gala/M9/MM106 3.0 x 1.0m (3333 trees/ha) “F” type trees produced 71.5 t/ha compared with 83 t on 3.0 x 0.5m (6666 trees/ha) “R” type planting material. Over the two seasons the increase in tree density from 3333 – 6666 trees/ha only added a further yield of 11.5t. That is, 100% rise in tree numbers only added 16% to crop volume.

Gala/MM106 3.5 x 1.0m (2857 trees/ha) “F” type trees at 79.5 t/ha also compared very favourably against the 3.0 x 0.5m (6666 trees/ha) “R” type on M9 rootstock. The extra 3809 trees/ha only delivered a further yield of 9.1t.

These examples clearly show how the nursery tree quality and tree density can affect some key aspects of orchard performance.

It should be noted that one year old Gala nursery trees only had medium quality “feathers”. By planting the highest quality nursery material (large trees with 8-10 feathers) at around 3000 trees/ha further benefits can be gained in comparison with “R” type established at 4444 - 6666 trees/ha.

This is well illustrated with Sundowner/MM106 (3.5 x 1.0m) “F” versus “R” at 3.0 x 0.5m and 3.0 x 0.75m spacings.

The best examples of very high cropping surface established with well developed one year old nursery trees can be observed in Pink Lady at lower densities. Better quality trees on M9/MM106 and M9/MM102 at 3.0 x 0.75m produced similar or higher crop volumes compared with "R" at 3.0 x 0.5 m spacings (+2222 trees/ha). "Moderate" density (3333 trees/ha) "F" with M9/MM106 and M26 performed well against the 6666 trees/ha density established with lower quality nursery material.

The most interesting results were obtained in Pink Lady. MM106 "F" at 2857 trees/ha which accumulated 106.9 t/ha and outyielded all other treatments in the planting. The same combination at 3.5 x 1.5 m (1904 trees/ha) also produced similar results.

A further increase in early yields can be achieved with "advanced" quality nursery trees raised over two seasons from a "benchgraft". These trees can have 7-10 feathers above 0.8m on a well developed 1.7-1.9m main stem. Single row intensive orchard hedgerows based on 2500-3500 trees per hectare can produce a full commercial crop of over 50 t/ha in the second season after planting.

Accumulated total yield can exceed 100 t/ha by the third year after planting. In addition to nursery tree quality and tree density, dwarfing – semi-dwarfing rootstocks, light pruning and tree training are very important factors in early fruit production.

Transfer of technology activities

- Modern intensive apple plantings based on sound and proven principles of orchard design – appropriate choice of variety, rootstock, tree quality, tree density and layout, tree training and level of pruning have been fully demonstrated in this project in close association with the industry
- Regular field days, orchard walks, seminars and workshops have been conducted during all important phases of orchard development with good participation by Tasmanian and interstate growers. Over 75% of local orchardists and their orchard employees attended some or most of the organised events at Grove Research Station. Also there have been numerous and repeated individual and small group inspections of the planting.
- Printed technical information has been disseminated to the industry via field day / seminar handouts, Tree Fruit Tasmania, Tree Fruits Australia and HAL and APAL publications.
- Comprehensive poster presentations were prepared for SnackFruit Conference, 2002 and APAL Conference, 2003.
- There is a permanent posted display at Grove Research Station which will be expanded in line with further monitoring of the planting.
- The demonstration orchard continues to attract interest from fruit growers. It will be maintained as a long term resource for the industry.

Table 1

Promoting branching (feathering) in Fuji "Ogura"/MM102
One-year-old nursery trees planted as 'rods' in September 2000
Treatments applied in late October 2000

Treatment	Total No. of trees in test	Mean No. of feathers / tree in 0.7 - 1.1m zone	Labour cost cents / tree
Control	16	5.4	-
Cytolin 15 mL/litre in 0.7-1.1m zone	19	5.7	4.5
Scored (v blade) at 1.1m	20	8.9	1.6
Scored (v blade) at 1.1m + Cytolin (15 mL/litre) in 0.7-1.1m zone	8	9.5	6.1
Bud notched (hacksaw) in 0.7-1.1m zone (10-12 buds)	20	10.9	28.0
Bud notched (hacksaw) +Cytolin (15 mL/litre) in 0.7-1.1m zone	20	10.6	32.5

Table 2 Intensive Orchard Development Costs**A. Planting Phase**

	Tree density/ha and spacing (m)				
	1904 (3.5 x 1.5)	2857 (3.5 x 1.0)	3333 (3.0 x 1.0)	4444 (3.0 x 0.75)	6666 (3.0 x 0.5)
	\$	\$	\$	\$	\$
Land preparation (grubbing, tree removal, ripping, hilling up, fumigation, fertilizers ...)	8579	8579	9189	9189	9189
Trellis support (posts, wires, tree ties, anchors)	7525	7525	8532	8532	8532
Irrigation system	2992	2992	3234	3234	3234
Trees	9520	14285	16665	22220	33330
Tree planting (manual) & tying to trellis	2665	4000	4666	6221	9332
Total (A)	31281	37381	42286	49396	63617

B. First season development phase

Pruning and tree training	425	637	743	991	1486
Growth control (Ethrel)	214	214	214	214	214
Weed control	262	262	302	302	302
Sprays	1227	1227	1227	1227	1227
Fertilizers (N)	175	175	175	175	175
Irrigation	300	300	300	300	300
Total (B)	2603	2815	2961	3209	3704
Grand Total (A+B)	33884	40196	45247	52605	67321

C. Orchard Production Costs (\$) – Year 2

Tree Training (tying down)	1470	2032	1672	1844	2147
Weed Control (weedicides & mowing)	562	562	828	828	828
Sprays	968	968	1024	1024	1024
Fertilizers (ground + foliar)	613	613	725	725	725
Irrigation	300	300	300	300	300
Total	3913	4475	4549	4721	5024

Production costs/variety

- HAND THINNING (\$):
Fuji 1340 – 3919; Gala 749 – 3804;
Sundowner 1715 – 4395; Pink Lady 864 – 2233
- SPRAY THINNING (\$) - 3m & 3.5 m row spacing:
Fuji 58 & 53; Gala *487 & 46;
Sundowner *494 & 484; Pink Lady 57 & 52
- TYING DOWN & PRUNING (\$):
Fuji 1095 – 3055; Gala 403 – 3040;
Sundowner 1599 – 3242; Pink Lady 2767 – 4481

* Cylex™ one application

Table 3

Orchard Production Costs (\$/ha) - Year 3
(averaged across all varieties)

	Tree density/ha and spacing (m)				
	1904	2857	3333	4444	6666
	(3.5 x 1.5)	(3.5 x 1.0)	(3.0 x 1.0)	(3.0 x 0.75)	(3.0 x 0.5)
	\$	\$	\$	\$	\$
Pruning	210	271	200	243	263
Hand Thinning	1815	2257	2601	3064	3345
Weed Control (weedicides & mowing)	448	448	653	653	653
Sprays	874	874	914	914	914
Fertilizers (ground + foliar)	706	706	741	741	741
Irrigation	300	300	300	300	300
Total	4353	4856	5409	5915	6216

SPRAY THINNING (\$) - 3.0m & 3.5 m row spacing:

Fuji	71 & 66;	Gala	61 & 56;
Sundowner	72 & 67;	Pink Lady	63 & 58

Table 3.1

Orchard Production Costs in Year 3
Manual Fruit Thinning Inputs (\$/ha)

Variety	Tree density/ha and spacing (m)				
	1904 (3.5 x 1.5)	2857 (3.5 x 1.0)	3333 (3.0 x 1.0)	4444 (3.0 x 0.75)	6666 (3.0 x 0.5)
Gala	2039	2829	2606	3294	3571
Fuji	1351	1790	1893	2306	2614
Pink Lady	1302	1439	2687	2677	3053
Sundowner	2567	2971	3217	3979	4144

Table 3.2

Orchard Production Costs in Year 3
Pruning Inputs (\$/ha)

Gala	131	181	132	214	208
Fuji	67	155	85	123	190
Pink Lady	421	475	268	306	320
Sundowner	223	274	317	331	335

Table 4

**Total fruit production performance (t/ha) in the
second season after planting
(all trees planted as "Rods" except where indicated F = "feathered trees")**

Tree Spacing (m)	Density per ha	M9 / MM106	M9 / MM102	M26	M9	MM102	MM106
FUJI							
3.0 x 0.5	6666	45.8	33.3	40.6	39.2		
3.0 x 0.75	4444	37.8	25.2	34.3	27.3	30.5	
3.0 x 1.0	3333	29.4	21.7	30.8		31.3	
3.5 x 1.0	2857					27.4	44.4
3.5 x 1.5	1904					27.8	32.5
SUNDOWNER							
3.0 x 0.5	6666	46.5	41.7	41.1			
3.0 x 0.75	4444	40.5	30.7	30.4			
		F 42.4	F 42.2	F 39.9			
3.0 x 1.0	3333	F35.4	F 33.8	F 32.7			
3.5 x 1.0	2857					27.6	35.8
						F 32.8	F 48.7
3.5 x 1.5	1904					F 27.8	F 26.1
GALA							
3.0 x 0.5	6666	39.3	34.7	36.6	39.8		
3.0 x 0.75	4444	32.6	28.3	32.2	F 34.4		
3.0 x 1.0	3333	26.6	24.4	21.8			
		F 32.7		F 25.4			
3.5 x 1.0	2857					20.5	32.1
						F 29.1	F 36.7
3.5 x 1.5	1904					18.8	21.0
						F 24.1	
3.0 x 0.25	13332				46.2		
PINK LADY							
3.0 x 0.5	6666	43.4	40.1	37.2	40.4		
3.0 x 0.75	4444	34.0	30.2	28.8			
		F 43.8	F 41.7	F 33.4			
3.0 x 1.0	3333	29.1	26.4	25.1			
		F 37.6	F 31.5	F 31.9		F 31.3	
3.5 x 1.0	2857						33.2
						F 31.6	F 42.1
3.5 x 1.5	1904					F 25.6	F 35.6

Table 5

**Effect of one year old nursery tree quality and tree heading
at planting on early production**

Variety/rootstock (tree spacing m)	Total yield in tonnes / hectare – year 2		
	"Rods"		"Feathers"
	Headed at 1.1 m	Not headed	Not headed
Sundowner / M9 / MM102 3.0 x 0.75	16.8	30.7	42.2
Sundowner / M26 3.0 x 0.75	22.4	30.4	39.9
Sundowner / MM102 3.5 x 1.0	19.8	27.6	38.3
Sundowner / MM106 3.5 x 1.0	24.3	35.8	48.7
Pink Lady / M9 / MM106 3.0 x 1.0	28.4	38.2	43.8
Pink Lady / M9 / MM102 3.0 x 0.75	23.2	31.0	41.7
Pink Lady / M26 3.0 x 0.75	21.0	28.8	33.4
Pink Lady / MM106 3.5 x 1.0	20.8	33.2	42.1

Table 6

**Total fruit production performance (t/ha) in the
third season after planting**

(all trees planted as "Rods" except where indicated F = "feathered trees")

Tree Spacing (m)	Density/ha	ROOTSTOCK					
		M9 / MM106	M9 / MM102	M26	M9	MM102	MM106
FUJI							
3.0 x 0.5	6666	46.2	31.5	42.5	35.5		
3.0 x 0.75	4444	38.4	24.0	38.6	35.1	25.8	
3.0 x 1.0	3333	33.6	22.3	34.7		28.4	
3.5 x 1.0	2857					22.5	44.1
3.5 x 1.5	1904					20.4	29.6
SUNDOWNER							
3.0 x 0.5	6666	46.6	40.2	44.5			
3.0 x 0.75	4444	46.4	33.0	40.3			
		F43.0	F35.8	F43.0			
3.0 x 1.0	3333	F37.8	F31.6	F37.5			
3.5 x 1.0	2857						37.3
							F38.5
3.5 x 1.5	1904						F29.8
GALA							
3.0 x 0.5	6666	43.7	40.5	47.9	48.8		
3.0 x 0.75	4444	43.6	39.2	45.1	F48.5		
3.0 x 1.0	3333	36.9	29.4	40.6			
		F38.8		F39.6			
3.5 x 1.0	2857					24.7	43.4
						F33.0	F42.8
3.5 x 1.5	1904					23.2	33.6
						F25.5	
3.0 x 0.25	13332				50.7		
PINK LADY							
3.0 x 0.5	6666	40.1	40.0	45.6	51.8		
3.0 x 0.75	4444	42.5	40.6	45.3			
		F53.9	F40.9	F43.1			
3.0 x 1.0	3333	41.5	37.5	52.7			
		F44.0	F33.2	F40.8		F47.1	
3.5 x 1.0	2857						54.2
						F50.8	F64.8
3.5 x 1.5	1904					F37.5	F59.5

Table 7

**Cumulative fruit production performance (t/ha) in the
second and third season after planting
(all trees planted as "Rods" except where indicated F = "feathered trees")**

Tree Spacing (m)	Density / ha	ROOTSTOCK					
		M9 / MM106	M9 / MM102	M26	M9	MM102	MM106
FUJI							
3.0 x 0.5	6666	92.2	64.8	83.1	74.7		
3.0 x 0.75	4444	76.2	49.2	72.9	62.4	56.3	
3.0 x 1.0	3333	63.0	44.0	65.5		59.7	
3.5 x 1.0	2857					49.9	88.5
3.5 x 1.5	1904					48.2	62.1
GALA							
3.0 x 0.5	6666	83.0	75.2	84.5	88.6		
3.0 x 0.75	4444	76.2	67.5	77.3	F82.9		
3.0 x 1.0	3333	63.5	53.8	62.4			
		F71.5		F65.0			
3.5 x 1.0	2857					45.2	75.5
						F62.1	F79.5
3.5 x 1.5	1904					42.0	54.6
						F49.6	
3.0 x 0.25	13332				96.9		
SUNDOWNER							
3.0 x 0.5	6666	93.1	81.9	85.6			
3.0 x 0.75	4444	86.9	63.7	70.7			
		F85.4	F78.0	F82.9			
3.0 x 1.0	3333	F73.2	F65.4	F70.2			
3.5 x 1.0	2857					49.3	73.1
						F63.0	F87.2
3.5 x 1.5	1904					F50.6	F55.9
PINK LADY							
3.0 x 0.5	6666	83.5	80.1	82.8	92.2		
3.0 x 0.75	4444	76.5	70.8	74.1			
		F97.7	F82.6	F76.5			
3.0 x 1.0	3333	70.6	63.9	77.8			
		F81.6	F64.7	F72.7		F78.4	
3.5 x 1.0	2857						87.4
						F82.4	F106.9
3.5 x 1.5	1904					F63.1	F95.1

**Intensive Apple Production Systems
Demonstration Orchard Planted in 2000
Grove Research Station**

- **Yield performance (summary) years 2 — 6**
- **Yield performance details, years 4 — 6**
- **Major annual production costs in year 6**

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Intensive Apple Production Systems
Demonstration Orchard Planted in 2000 at Grove Research Station
Yield performance (t/ha) for years 2 — 6 (2002-2006)
(Summary)

Variety: Gala

Rootstock	Spacing (m)	Density /ha	Years					Total
			2	3	4	5	6	
M9/MM106	3.0 x 0.5	6666	39.3	43.7	37.6	43.1	37.4	201.1
	3.0 x 0.75	4444	32.6	43.6	31.7	42.4	30.8	181.1
	3.0 x 1.0	3333	26.6	36.9	25.2	35.7	32.8	157.2
			F32.7	F38.8				
M9/MM102	3.0 x 0.5	6666	34.7	40.5	36.7	30.3	37.0	179.2
	3.0 x 0.75	4444	28.3	39.2	29.8	30.6	34.8	162.7
	3.0 x 1.0	3333	24.4	29.4	24.1	23.1	25.7	126.7
M26	3.0 x 0.5	6666	36.6	47.9	32.3	36.1	45.1	198.0
	3.0 x 0.75	4444	32.2	45.1	26.0	34.0	40.1	177.4
	3.0 x 1.0	3333	21.8	40.6	27.4	32.0	33.1	154.9
			F25.4	F39.6				
M9	3.0 x 0.5	6666	39.8	48.8	35.8	76.5	48.3	249.2
	3.0 x 0.75	4444	F34.4	F48.5	34.0	30.1	43.9	190.9
	3.0 x 0.25	13332	46.2	50.7	34.6	50.6	48.8	230.9
MM102	3.5 x 1.0	2857	20.5	24.7	25.3	16.8	21.9	109.2
			F29.1	F33.0				
	3.5 x 1.5	1904	18.8	23.2	23.2	25.1	20.5	110.8
			F24.1	F25.5				
MM106	3.5 x 1.0	2857	32.1	43.4	17.0	30.8	16.6	139.9
			F36.7	F42.8				
	3.5 x 1.5	1904	21.1	33.6	16.5	20.6	15.2	107.0

Variety: Pink Lady

Rootstock	Spacing (m)	Density /ha	Years						Total
			2	3	4	5	6		
M9/MM106	3.0 x 0.5	6666	43.4	40.1	49.2	61.0	45.3	239.0	
	3.0 x 0.75	4444	34.0 F43.8	42.5 F53.9	34.7	63.9	40.5	215.6	
M9/MM102	3.0 x 1.0	3333	29.1 F37.6	41.5 F44.0	28.9	62.4	45.2	207.1	
	3.0 x 0.5	6666	40.1	40.0	23.7	53.5	56.4	213.7	
M26	3.0 x 0.75	4444	30.2 F41.7	40.6 F40.9	20.5	51.3	43.7	186.3	
	3.0 x 1.0	3333	26.4 F31.5	37.5 F33.2	22.0	45.0	53.3	184.2	
M9	3.0 x 0.5	6666	37.2	45.6	25.5	58.9	26.6	193.8	
	3.0 x 0.75	4444	28.8 F33.4	45.3 F43.1	23.0	60.0	28.5	185.6	
MM102	3.0 x 1.0	3333	25.1 F31.9	52.7 F40.8	15.8	59.5	32.5	185.6	
	3.0 x 0.5	6666	40.4	51.8	42.9	74.6	51.2	260.9	
MM106	3.0 x 0.75	4444	F36.4	63.3	29.3	42.9	60.6	232.5	
	3.0 x 1.0	3333	F31.3	F47.1	17.7	43.4	34.9	178.4	
MM106	3.5 x 1.0	2857	F31.6	F50.8	15.1	44.6	36.9	159.5	
	3.5 x 1.5	1904	F25.6	F37.5	14.6	48.2	24.3	174.5	
MM106	3.5 x 1.0	2857	33.2 F42.1	54.2 F64.8	12.2	41.7	20.7	169.7	
	3.5 x 1.5	1904	F35.6	F59.5					

Intensive Apple Growing Systems, Grove

Gala fruit production in year 6 (2006)

Stock	Spacing (m)	Trees/ha	Yield t/ha	Size count/13.5 kg	g/apple
M9/MM106	3 x 0.5	6666	37.4	97	138.5
	3 x 0.75	4444	30.8	89	152.4
	3 x 1	3333	32.8	87	155.1
M9/MM102	3 x 0.5	6666	37.0	98	137.9
	3 x 0.75	4444	34.8	91	148.1
	3 x 1	3333	25.7	82	165.3
M26	3 x 0.5	6666	45.1	100	135.5
	3 x 0.75	4444	40.1	92	146.7
	3 x 1	3333	33.1	88	153.1
M9	3 x 0.5	6666	48.3	93	144.7
	3 x 0.75	4444	43.9	90	149.2
	3 x 0.25	13332	48.8	96	140.7
MM102	3.5 x 1	2857	21.9	87	155.2
	3.5 x 1.5	1904	20.5	83	162.8
MM106	3.5 x 1	2857	16.6	96	140.6
	3.5 x 1.5	1904	15.2	91	148.7

Intensive Apple Growing Systems, Grove

Pink Lady fruit production in year 6 (2006)

Stock	Spacing (m)	Trees/ha	Yield t/ha	Size count/13.5 kg	g/apple
M9/MM106	3 x 0.5	6666	45.3	96	141.3
	3 x 0.75	4444	40.5	84	161.1
	3 x 1	3333	45.2	86	156.6
M9/MM102	3 x 0.5	6666	56.4	87	154.8
	3 x 0.75	4444	43.7	82	164.8
	3 x 1	3333	53.3	86	157.8
M26	3 x 0.5	6666	26.6	81	167.0
	3 x 0.75	4444	28.5	77	174.3
	3 x 1	3333	32.5	78	173.4
M9	3 x 0.5	6666	51.2	88	153.7
MM102	3 x 0.75	4444	60.6	84	161.3
	3.5 x 1	2857	34.9	82	165.1
	3.5 x 1.5	1904	36.9	80	168.3
MM106	3.5 x 1	2857	24.3	80	169.2
	3.5 x 1.5	1904	20.7	80	169.5

Intensive Apple Growing Systems, Grove

Gala fruit production in years 4 and 5 (2004 and 2005)

Stock	Spacing (m)	Trees/ha	Yield t/ha		Size count/13.5 kg	
			Year 4	Year 5	Year 4	Year 5
M9/MM106	3 x 0.5	6666	37.6	43.1	88	82
	3 x 0.75	4444	31.7	42.4	78	84
	3 x 1	3333	25.2	35.7	80	73
M9/MM102	3 x 0.5	6666	36.7	30.3	87	72
	3 x 0.75	4444	29.8	30.6	80	67
	3 x 1	3333	24.1	23.1	83	69
M26	3 x 0.5	6666	32.3	36.1	79	92
	3 x 0.75	4444	26.0	34.0	75	80
	3 x 1	3333	27.4	32.0	80	81
M9	3 x 0.5	6666	35.8	76.5	73	84
	3 x 0.75	4444	34.0	30.1	76	76
	3 x 0.25	13332	34.6	50.6	75	88
MM102	3.5 x 1	2857	25.3	16.8	99	88
	3.5 x 1.5	1904	23.2	25.1	90	82
MM106	3.5 x 1	2857	17.0	30.8	73	88
	3.5 x 1.5	1904	16.5	20.6	82	85

Intensive Apple Growing Systems, Grove

Pink Lady fruit production in years 4 and 5 (2004 and 2005)

Stock	Spacing (m)	Trees/ha	Yield t/ha		Size count/13.5 kg	
			Year 4	Year 5	Year 4	Year 5
M9/MM106	3 x 0.5	6666	49.2	61.0	92	87
	3 x 0.75	4444	34.7	63.9	76	81
	3 x 1	3333	28.9	62.4	74	79
M9/MM102	3 x 0.5	6666	23.7	53.5	74	76
	3 x 0.75	4444	20.5	51.3	77	72
	3 x 1	3333	22.0	45.0	73	68
M26	3 x 0.5	6666	25.5	58.9	72	82
	3 x 0.75	4444	23.0	60.0	67	78
	3 x 1	3333	15.8	59.5	69	78
M9	3 x 0.5	6666	42.9	74.6	79	81
MM102	3 x 0.75	4444	29.3	42.9	81	66
	3.5 x 1	2857	17.7	43.4	75	74
	3.5 x 1.5	1904	15.1	44.6	76	73
MM106	3.5 x 1	2857	14.6	48.2	76	82
	3.5 x 1.5	1904	12.2	41.7	76	81

**Intensive Apple Production Systems - Grove
Orchard Production Costs (\$/ha) - Year 6
(averaged across Gala and Pink Lady)**

	Tree density/ha and spacing (m)				
	1904 (3.5 x 1.5) \$	2857 (3.5 x 1.0) \$	3333 (3.0 x 1.0) \$	4444 (3.0 x 0.75) \$	6666 (3.0 x 0.5) \$
Pruning	1513	1354	1510	1574	1520
Hand Thinning	1700	1770	1737	1969	2193
Weed Control	678	678	723	723	723
Mowing	293	293	327	327	327
Sprays/Foliar Fertilisers	1720	1720	1813	1813	1813
Fertilisers (ground)	403	403	407	407	407
Irrigation	400	400	400	400	400
Total	6414	6325	6590	6886	7056

Intensive Apple Production Systems - Grove
Pink Lady - Pruning and Hand Thinning — Hrs/ha and \$/ha
Year 6 (2006)

Stock	Spacing (m)	Trees/ha	Pruning		Hand Thinning	
			Man Hrs / ha	\$/ha (\$18.68/hr)	Man Hrs / ha	\$/ha (\$18.68/hr)
M9 / MM106	3 x 0.5	6666	103	1924	152	2839
	3 x 0.75	4444	62	1158	148	2765
	3 x 1	3333	86	1606	132	2466
M9 / MM102	3 x 0.5	6666	88	1644	110	2055
	3 x 0.75	4444	125	2335	115	2148
	3 x 1	3333	84	1569	77	1438
M26	3 x 0.5	6666	136	2540	131	2447
	3 x 0.75	4444	111	2073	126	2354
	3 x 1	3333	127	2372	154	2877
M9	3 x 0.5	6666	42	785	198	3699
MM102	3.5 x 1	2857	75	1401	101	1887
	3.5 x 1.5	1904	96	1793	107	1999
MM106	3.5 x 1	2857	91	1700	144	2690
	3.5 x 1.5	1904	106	1980	123	2298

**Intensive Apple Production Systems - Grove
Gala - Pruning and Hand Thinning — Hrs/ha and \$/ha
Year 6 (2006)**

Stock	Spacing (m)	Trees/ha	Pruning		Hand Thinning	
			Man Hrs / ha	\$/ha (\$18.68/hr)	Man Hrs / ha	\$/ha (\$18.68/hr)
M9 / MM106	3 x 0.5	6666	82	1532	92	1719
	3 x 0.75	4444	74	1382	93	1737
	3 x 1	3333	56	1046	74	1382
M9 / MM102	3 x 0.5	6666	42	785	54	1009
	3 x 0.75	4444	46	859	68	1270
	3 x 1	3333	35	654	53	990
M26	3 x 0.5	6666	89	1663	99	1849
	3 x 0.75	4444	99	1849	83	1550
	3 x 1	3333	97	1812	68	1270
M9	3 x 0.5	6666	68	1270	103	1924
	3 x 0.75	4444	73	1364	105	1961
	3 x 0.25	13332	98	1830	113	2111
MM102	3.5 x 1	2857	37	692	25	467
	3.5 x 1.5	1904	55	1027	47	878
MM106	3.5 x 1	2857	87	1625	109	2036
	3.5 x 1.5	1904	67	1252	87	1625