

# Influence of Training System on Production of Three Apple Cultivars

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**Introduction:**

Intensive orchard planting systems are becoming more common in the mid-Atlantic apple production region. Orchard systems are the result of combining the cultivar and rootstock at a particular spacing and then training and pruning trees to achieve maximum production. Baugher et. al. (1994) had shown that certain systems may initially have a high productivity but may not be able to maintain that level of production as the trees mature. They also suggested that medium to high density vertical or inclined canopy systems were superior to horizontal or low density vertical free standing systems. Further work (Kurahashi and Takahashi, 1995), with 'Fuji' also supports the concept that angled canopies may be more efficient. Canopies trained to a "Y" system had more efficient dry matter production and higher assimilate partitioning into fruit than that in a central leader system. In New York yields for Empire in the first 5 years after planting were positively correlated to tree density (Robinson et. al., 1991). In the second 5 years, however, Empire/M.26 on a "Y" trellis had the highest yields. When yield efficiency was evaluated Empire/M.9 trained as a slender spindle was the best system. In a British Columbia study the higher early yields for both 'McIntosh' and 'Delicious' were obtained in slender spindle and vertical axe systems on a per acre basis (Kappel and Quamme, 1993).

**Methods:**

An orchard consisting of three cultivars on M.9 T337, 'Crimson Gala', 'Ginger Gold' and 'Fuji' (BC#2) was established in 1997 at the Horticultural Research Farm at Rock Springs, PA in north to south rows. Each cultivar has a distinctive growth/fruiting pattern. Four training systems were selected and established, vertical axe (A), slender spindle (SS), 4-wire low trellis (T) and an offset V-axe (VA). Trees in the A, SS and T systems were set at 1.8 x 3.6 m (1495 trees/ha). The VA was planted at 0.9 x 4.9 m (2241 trees/ha) with every other tree oriented at 60° to the east or west. Data collected or calculated each year included trunk cross sectional area (TCA) annual increase in growth of TCA, number of fruit per tree, yield per tree (kg), efficiency (g/cm<sup>2</sup>), crop load (#/cm<sup>2</sup>), and yield per ha (kg). All data was subjected to analysis of variance and when significant mean separation was performed by the Tukey-Kramer mean separation with probability of 0.05.



Figure 1. Examples of the apple training systems for Gala/M.9 at the end of the 10<sup>th</sup> growing season; A = V-Axe, B = Spindle, C = Axe, and D = Trellis. (Scale: posts in B & D = 1.8m, C = 2.7m.)

Table 2. Mean tree height (cm) at the end of the 10<sup>th</sup> growing season by system and cultivar

	'Ginger Gold'	'Gala'	'Fuji'	
V Axe	361 b	354 b	304a	
Spindle	362 b	363 b	337a	
Axe	415a	433a	345a	
Trellis	203 c	202 c	200 b	
P - Value	0.0001	0.0001	0.0001	
	V Axe	Spindle	Axe	Trellis
'Ginger Gold'	361a	362ab	415a	203a
'Gala'	354a	363a	433a	202a
'Fuji'	304 b	337 b	345 b	200a
P - Value	0.0021	0.0326	0.0001	0.5129

Letters refer to Tukey-Kramer mean separation, P=0.05

Table 1. Trunk cross sectional area (cm<sup>2</sup>) at end of 10<sup>th</sup> growing season analyzed by system.

	V-Axe	Spindle	Axe	Trellis
'Ginger Gold'	33.3 b	47.1 b	47.7 a	38.5 b
'Gala'	36.1 b	47.8 b	50.6 a	39.0 b
'Fuji'	45.0 a	63.9 a	55.2 a	61.3 a
P - Value	0.0013	0.0011	0.1128	0.0001

Letters refer to Tukey-Kramer mean separation, P=0.05

Table 3. Cumulative yield (kg/tree) of 'Ginger Gold', 'Gala', and 'Fuji' in 1999-2006 analyzed by system.

	'Ginger Gold'	'Gala'	'Fuji'
V-Axe	214.0 b	195.8 b	210.4 c
Spindle	224.5 b	208.8 b	317.8 bc
Axe	278.1a	287.0a	336.3a
Trellis	195.1 b	204.3 b	280.0 bc
P - Value	0.0020	0.0011	0.0001

Letters refer to Tukey-Kramer mean separation, P=0.05

**Results:**

There were a number of system by cultivar interactions. Within cultivars 'Fuji' were the largest trees in all training systems followed by 'Gala' and then 'Ginger Gold' (Table 1). In general the tallest trees were those trained to the A; while the shortest were those in the T system (Table 2). Within a system 'Fuji' tended to be the shortest trees; significantly so for three out of four systems. Within each cultivar the cumulative yield per tree has been greatest for trees trained to the A, although with 'Fuji' the yields were not significantly different from the SS or T (Table 3). The lowest yields per tree were consistently from trees trained to the VA; although for 'Ginger Gold' and 'Gala' they were not significantly lower than the other two systems. In the SS and the T 'Fuji' had significantly greater per tree yields than either 'Ginger Gold' or 'Gala'. Cumulative yields on a per hectare basis for 'Ginger Gold' and 'Gala' was greatest on the VA system but not significantly better than trees trained to the A system (Table 4). With 'Fuji' the greatest yields were on trees in the A system but not significantly better than the VA or SS system. In general due to the shorter height of the T system yields were lower. In individual years yields per ha tended to be greater for the VA system but on a per tree basis the A system generally had the highest yields (Table 5).

Table 4. Cumulative yield (kg/ha x 1000) of 'Ginger Gold', 'Gala' and 'Fuji' in kg / ha., 1999-2006 analyzed by system.

	Ginger Gold	Gala	Fuji
V-Axe	217.6a	199.0a	213.9ab
Spindle	152.2 bc	141.5 b	215.5ab
Axe	188.5ab	194.6a	228.0a
Trellis	132.3 c	138.5 b	189.9 b
P - Value	0.0003	0.0007	0.0270

Letters refer to Tukey-Kramer mean separation, P=0.05

Table 5. Highest yielding system for each cultivar in each year in kg/ha and kg/tree

Cultivar	kg / ha							
	1999	2000	2001	2002	2003	2004	2005	2006
'Ginger Gold'	VA <sup>z</sup>	VA	VA	A	VA	<b>VA<sup>y</sup></b>	<b>VA</b>	A
'Gala'	VA	VA	VA	A	A	<b>VA</b>	VA	<b>VA</b>
'Fuji'	T	SS	A	T	A	VA	A	<b>A</b>
kg / tree								
'Ginger Gold'	SS	SS	A	<b>A</b>	A	<b>A</b>	A	A
'Gala'	T	A	A	<b>A</b>	<b>A</b>	<b>A</b>	A	<b>A</b>
'Fuji'	T	<b>SS</b>	A	T	A	<b>A</b>	A	<b>A</b>

<sup>z</sup> VA = V-Axe, SS = Slender spindle, A = Axe, T = Trellis  
<sup>y</sup> Italicized boldface type indicates a mean significantly different from more 2 or more training systems

**References**

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