Growth, Yield, and Fruit Weight of Spur-bound 'Delicious' Apple Trees following Spur-pruning and BA Plus GA₄₊₇ Application

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Abstract. Twenty-eight-year-old 'Starkrimson Delicious' and 10-year-old 'Fullred Delicious' apple (*Malus domestics* Borkh.) trees were spur-pruned in 1986 and 1987 and/or treated with 500 mg BA + GA₄₊₇/liter in 1986 in an attempt to improve spur growth and increase fruit weight. All treatment combinations generally failed to improve yield or fruit size. BA + GA₄₊₇ reduced yield and fruit weight and increased the number of pygmy fruit in 1986, but had little effect on fruiting or vegetative growth for 3 years after treatment. Spur-pruning reduced spur density in 1986 and 1987 and increased yield, but not fruit weight, in 1987. Although spur-pruning improved spur length, spur bud diameter, leaf area per spur, and leaf dry weight per spur, fruit weight was not improved. Chemical names used: *N*-(phenylmethyl)-1H-purine-6-amine [benzyladenine (BA)]; gibberellin (GA₄₊₇).

Most 'Delicious' apple trees planted during the past 20 to 30 years have been spur-type strains. As these trees age, they become less vigorous and produce little extension growth. Mature spur 'Delicious' trees often have extensive spur systems, crop heavily, and are difficult to thin chemically; the result is biennial bearing and the production of small fruit.

Spur quality influences flowering, fruit set, and 'fruit size'. Flowering (Roberts, 1952) and fruit set (Auchter and Schrader, 1923) were positively related to spur length; fruit set was positively correlated with spur bud size (Blasberg, 1943); and apple yield was positively correlated with leaf area per spur during bloom (Rem and Ferree, 1984).

Attempts to alter spur quality have produced variable results. Cutting multiple spurs and short shoots in half increased shoot growth, flower size, leaf area per spur, length of secondary shoots, fruit set, and fruit size in spur-bound 'Golden Delicious' trees (Roberts, 1952). Spur-pruning and foliar urea applications to scaffold branches did not improve spur quality in mature 'Starkrimson Delicious' trees, but heading-back into 2-year-old wood of spur-bound 'Redchief Delicious' branches increased the leaf area of both shoots and spurs and improved fruit size (Ferree and Forshey, 1988).

Since spurs with bourse shoots had the greatest leaf area per spur, and the greatest number and total weight of fruit (Ferree and Palmer, 1982), treatments that stimulate bourse shoot development might be beneficial. Applications of BA + GA₄₊₇ increased leaf size (McLaughlin and Greene, 1984), primary and secondary branching, and total shoot growth of apples (Forshey, 1982). Therefore, early season applications of BA + GA₄₊₇ might improve spur quality. The purpose of this study was to determine the individual and interrelated effects of spur-pruning and BA + GA₄₊₇ on spur quality and fruit size of mature, spur-bound and young, vigorous 'Delicious' apple trees.

Materials and Methods

Seventeen 28-year-old 'Starkrimson Delicious' trees on seedling rootstock and nine 10-year-old 'Fullred Delicious' trees on MM.111 rootstock, growing in Stuart, Va., were used for this study. The 'Starkrimson Delicious' had become spur-bound and nonvigorous: terminal shoot growth at 2 m above ground averaged ≈10 cm. These trees were cropping somewhat biennially and had a light crop in 1985. The 'Fullred Delicious' were not yet spur-bound and had terminal shoots 40 to 60 cm long and a moderate crop in 1985. These two spur-type strains were considered separate experiments because they were in different orchards.

On 4 Apr. 1986, during the early pink flower stage (pink), four lower scaffold branches around each tree were randomly assigned to the following treatments: 1) nonpruned control, 2) spur-pruned—all spurs on the underside of the scaffold were removed and all remaining multiple-spur systems were cut in half, 3) nonpruned, but sprayed to runoff with a hand sprayer with BA + GA₄₊₇ each at a concentration of 500 mg·liter⁻¹ with 0.1% Tween 20 surfactant, 4) spur-pruned plus BA + GA₄₊₇. About one-third of the secondary branches arising from each scaffold branch were marked and were not used for data collection. Trees were chemically thinned annually, when fruit diameter averaged 9.0 to 9.5 mm, with a mixture of 1.8 g carbaryl + 0.12 ml Tween 20 + 5 mg NAA/liter. BA + GA₄₊₇ was applied only in 1986, and branches were spur-pruned in 1986 and 1987.

Annually, during pink, the cross-sectional area of each branch and the number of flowering and nonflowering growing points were recorded. At ≈140 days after bloom, fruit on each branch were counted and weighed, and the number of pygmy (<4 cm in diameter) fruit was recorded. Terms and units of measure for the various yield characteristics were expressed according to Lombard et al. (1988). Before harvest in 1986, two spurs, without bourse shoots but with single fruits, were sampled from the terminal, middle, and basal portions of each branch. These fruit were weighed and length : diameter (L:D) ratios were determined. Terminal bud diameter, length of current-season spur

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Abbreviations: CD, crop density; FI, flowering index; FS, fruit set; FSD, flowering spur density; FW, fruit weight; PD, pygmy density; SLW, specific leaf weight; VSD, vegetative spur density; YE, yield efficiency.

growth, number of leaves, leaf area, and leaf dry weight were determined for each spur. After harvest in 1989, two nonfruiting spurs without bourse shoots from the same branch positions were sampled and measured as in 1986. After leaf fall in 1989, six spurs were sampled from the same branch positions of seven 'Starkrimson Delicious' trees. The length of annual growth occurring each year from 1986 to 1989 and the number of fruit scars per spur were recorded.

Treatments were arranged as a 2 x 2 factorial in a randomized complete block design, and trees served as blocks. Data were analyzed with the analysis of variance procedure of SAS (SAS, 1985). When interactions were not significant ($P \leq 0.05$), means for main effects were presented. When interactions were significant, means for the various treatment combinations were compared with Tukey's HSD ($P = 0.05$).

Results

'Starkrimson Delicious'. Since spur-pruning and BA + GA₄₊₇ usually influenced flowering and fruiting characteristics independently, means for main effects are presented in Table 1. Spur-pruning significantly reduced the density of flowering (FSD) and vegetative spurs (VSD) in 1986 and 1987, but not thereafter (data not shown). In 1987 only, spur-pruning reduced the flowering index (FI), crop density (CD), and yield efficiency (YE), but increased fruit set (FS). Spur-pruning did not influence fruit weight (FW) in any year. BA + GA₄₊₇ increased the VSD in 1986 and 1987 and increased FS in 1987. BA + GA₄₊₇ reduced YE and FW, but increased the density of pygmies (PD) in 1986 (Table 1).

In 1986, spur-pruning increased spur length, terminal bud diameter, leaf area per spur, dry weight of leaves per spur, and FW (Table 2). BA + GA₄₊₇ increased leaf number per spur and fruit L:D ratio, but reduced FW. Terminal bud diameter, leaf area per spur, and specific leaf weight (SLW) were greatest at the terminal branch position. Spur length, FW, and fruit L:D ratio were influenced by the interactive effects of BA + GA₄₊₇ and branch position. Branches that were spur-pruned without

BA + GA₄₊₇ had longer spurs at the middle and basal positions than at the terminal position. Fruit weight was greatest at the middle and basal positions of branches not treated with BA + GA₄₊₇ and least for the middle position of nonpruned branches treated with BA + GA₄₊₇. Fruit L:D ratio was greatest at the middle and basal positions of branches treated with BA + GA₄₊₇ and smallest on the nonpruned branches not treated with BA + GA₄₊₇.

In 1989, spur-pruning (1986 + 1987) and BA + GA₄₊₇ (1986) did not significantly influence any characters of spur quality (Table 3). Spur length, number of leaves per spur, and SLW were greatest at the terminal position. Terminal bud diameter was greatest at the terminal positions of nonpruned branches and smallest at the basal position. Leaf area per spur was greatest at the terminal position and least at the basal position. Leaf dry weight per spur generally declined from the branch terminal toward the basal position.

Spur-pruning increased the terminal growth of spurs each year, whereas BA + GA₄₊₇ increased spur growth in 1986 and 1988 (Table 4). Spurs at the terminal position had the greatest spur extension in 1986 and 1989. Spurs on nonpruned branches had more fruit than on spur-pruned branches in 1986–1988, and BA + GA₄₊₇ reduced number of fruit per spur in 1986 and 1987. The terminal spurs produced the fewest fruit per spur in 1986 and 1989.

'Fullred Delicious'. Spur-pruning reduced FSD and total spurs all 4 years (data not shown). BA + GA₄₊₇ had minimal effect on all reproductive response variables measured (data not shown). Spur pruning and BA + GA₄₊₇ did not affect FI, FS, CD, YE, or FW in any year (data not shown). In 1986, spur-pruning increased terminal spur bud diameter, leaf area per spur, and leaf dry weight per spur, whereas BA + GA₄₊₇ reduced FW (Table 5). Spur length in 1986 was greatest at the basal and least at the terminal position of nonpruned branches treated with BA + GA₄₊₇. SLW was greatest at the terminal position and on spur-pruned branches not treated with BA + GA₄₊₇. Fruit L:D ratio was greatest on branches treated with BA + GA₄₊₇.

Table 1. Effect of spur-pruning in 1986 and 1987 and BA + GA₄₊₇ in 1986 on FSD, VSD, FI, FS, CD, YE, FW, and PD of 'Starkrimson Delicious' in 1986 and 1987.

Treatment	FSD (flowering spurs/cm ²)	VSD (vegetative spurs/cm ²)	FI (flowering spurs/total spurs)	FS (fruit/ flowering spur)	CD (fruit/cm ²)	YE (kg/cm ²)	FW (g/fruit)	PD (pygmies/cm ²)
1986								
Nonpruned	8.6	1.3	0.86	0.11	0.6	0.08	119	0.33
Spur-pruned	4.9	0.9	0.84	0.15	0.6	0.07	117	0.18
No BA + GA ₄₊₇	6.6	1.0	0.87	0.14	0.8	0.11	130	0.04
BA + GA ₄₊₇	7.0	1.3	0.84	0.13	0.4	0.04	105	0.48
F test significance								
Pruned	***	*	NS	NS	NS	NS	NS	NS
BA + GA ₄₊₇	NS	**	*	NS	NS	***	**	***
Pruned × BA + GA ₄₊₇	NS	NS	NS	NS	NS	NS	NS	*
1987								
Nonpruned	5.2	4.6	0.50	0.39	1.8	0.20	107	0.22
Spur-pruned	2.4	3.5	0.41	0.51	1.2	0.14	156	0.16
No BA + GA ₄₊₇	3.9	3.4	0.49	0.40	1.5	0.17	155	0.18
BA + GA ₄₊₇	3.6	4.7	0.42	0.50	1.4	0.16	109	0.20
F test significance								
Pruned	*	NS	*	*	*	*	NS	NS
BA + GA ₄₊₇	NS	*	NS	*	NS	NS	NS	NS
Pruned × BA + GA ₄₊₇	NS	NS	NS	NS	NS	NS	NS	NS

NS, *, **, *** Not significant or significant at $P = 0.05$, 0.01, and 0.001, respectively (n = 17).

Table 2. Effect of spur-pruning in 1986 and 1987, BA + GA₄₊₇ in 1986, and branch position on spur characteristics and fruit weight of 'Starkrimson Delicious' trees in 1986.^{z,y}

Treatment	Position	Spur length (cm)	Bud diam (mm)	Leaves/spur	Leaf area/spur (cm ²)	Leaf dry wt/spur (g)	SLW (mg·cm ⁻²)	FW (g)	Fruit L:D
Nonpruned, no BA + GA ₄₊₇	Terminal	1.8 bc	3.1	11.3	104	1.9	8.9	102 b	0.92 c
	Middle	2.3 ab	3.1	12.0	105	1.7	8.0	116 ab	0.91 c
	Basal	2.5 ab	3.2	10.7	107	1.5	6.9	132 a	0.91 c
Nonpruned, BA + GA ₄₊₇	Terminal	1.9 bc	3.1	12.3	111	1.8	8.2	105 ab	0.96 bc
	Middle	1.8 bc	3.1	12.9	109	1.7	7.8	94 b	1.00 ab
	Basal	2.2 ab	3.0	11.7	107	1.5	7.1	109 ab	0.99 ab
Pruned, no BA + GA ₄₊₇	Terminal	1.4 c	3.2	11.5	106	1.9	8.8	115 ab	0.92 c
	Middle	2.7 a	3.3	11.9	115	1.8	8.0	133 a	0.92 c
	Basal	2.7 a	3.1	11.1	119	1.7	7.0	131 a	0.94 bc
Pruned, BA + GA ₄₊₇	Terminal	2.4 ab	3.6	13.1	140	2.5	9.0	106 ab	0.95 bc
	Middle	2.4 ab	3.2	13.5	116	1.8	7.9	112 ab	1.00 ab
	Basal	2.4 ab	3.1	13.4	128	1.7	6.7	100 b	1.01 a
F test significance									
Spur-pruned (SP)		*	*	NS	**	*	NS	*	NS
BA + GA ₄₊₇ (BG)		NS	NS	**	NS	NS	NS	**	**
Position (P)		**	*	NS	NS	*	**	*	*
SP × BG		NS	NS	NS	NS	NS	NS	NS	NS
SP × P		NS	NS	NS	NS	NS	NS	*	NS
BG × P		**	NS	NS	NS	NS	NS	**	**
SP × BG × P		NS	NS	NS	NS	NS	NS	NS	NS

^zValues are means of 34 observations.

^yFor variables with significant interactions, means within columns followed by the same letter do not differ significantly ($P = 0.05$), Tukey's HSD.

^{ns} * ** Not significant or significant at $P = 0.05$ and 0.01 , respectively.

Table 3. Effect of spur-pruning in 1986 and 1987, BA + GA₄₊₇ in 1986, and branch position on spur characteristics of 'Starkrimson Delicious' trees in 1989.^{z,y}

Treatment	Position	Spur length (cm)	Bud diam (mm)	Leaves/spur	Leaf area/spur (cm ²)	Leaf dry wt/spur (g)	SLW (mg·cm ⁻²)
Nonpruned, no BA + GA ₄₊₇	Terminal	10.4	4.6 ab	9.2	126 a	0.9 a	7.4
	Middle	10.8	4.3 ab	8.7	113 ab	0.8 ab	7.9
	Basal	6.6	3.5 c	6.6	76 b	0.4 d	5.0
Nonpruned, BA + GA ₄₊₇	Terminal	10.9	4.7 a	9.4	126 a	0.8 ab	6.6
	Middle	9.0	4.1 abc	8.4	94 ab	0.6 bcd	6.1
	Basal	7.6	3.5 c	7.5	98 ab	0.5 cd	4.8
Pruned, no BA + GA ₄₊₇	Terminal	10.1	4.1 abc	8.4	106 ab	0.7 abc	6.4
	Middle	9.7	4.2 abc	8.7	125 a	0.8 ab	6.0
	Basal	6.5	3.5 c	7.8	86 ab	0.4 d	4.9
Pruned, BA + GA ₄₊₇	Terminal	11.5	4.4 ab	9.2	109 ab	0.7 abc	6.8
	Middle	11.4	4.0 abc	8.1	98 ab	0.6 bcd	6.1
	Basal	8.6	3.8 bc	7.7	100 ab	0.5 cd	5.1
F test significance							
Spur-pruned (SP)		NS	NS	NS	NS	NS	NS
BA + GA ₄₊₇ (BG)		NS	NS	NS	NS	NS	NS
Position (P)		**	**	**	**	**	**
SP × BG		NS	NS	NS	NS	NS	NS
SP × P		NS	*	NS	NS	*	NS
BG × P		NS	NS	NS	**	*	NS
SP × BG × P		NS	NS	NS	NS	NS	NS

^zValues are means of 34 observations.

^yFor variables with significant interactions, means within columns followed by the same letter do not differ significantly ($P = 0.05$), Tukey's HSD.

^{ns} * ** Not significant or significant at $P = 0.05$ and 0.01 , respectively.

and smallest on spur-pruned branches not treated with BA + GA₄₊₇ (Table 5).

In 1989, spur length and leaf area per spur were greatest for spur-pruned branches and for the terminal portion of the branches (Table 6). Spur characters were not affected by BA + GA₄₊₇

but most characters were influenced by the interaction of spur-pruning and branch position. Spur bud diameter was greatest at the terminal position of nonpruned branches and smallest at the basal portion of the same branches. Leaf area per spur, leaf dry weight per spur, and SLW were generally greatest at the ter-

Table 4. Effect of spur-pruning in 1986 and 1987, BA + GA₄₊₇ in 1986 and branch position on annual spur extension and fruit per spur on 'Starkrimson Delicious' trees.^{z,y}

Treatment and position	Spur extension (mm)				Fruit/spur			
	1986	1987	1988	1989	1986	1987	1988	1989
Nonpruned	16	14	15	14	0.87	0.73	0.41	0.84
Pruned	25	23	26	19	0.79	0.53	0.26	0.82
No BA + GA ₄₊₇	14	17	18	17	0.88	0.71	0.31	0.82
BA + GA ₄₊₇	26	20	23	16	0.79	0.56	0.36	0.84
Terminal	23 a	20	21	27 a	0.77 b	0.59	0.21 b	0.77 b
Middle	20 ab	17	19	11 b	0.87 a	0.66	0.40 a	0.88 a
Basal	18 b	18	20	10 b	0.84 ab	0.63	0.40 a	0.84 ab
F test significance								
Spur-pruned (SP)	**	**	**	**	**	**	**	NS
BA + GA ₄₊₇ (BG)	**	NS	*	NS	**	**	NS	NS
SP × BG	**	NS	NS	**	*	NS	NS	NS
Position (P)	**	NS	NS	*	*	NS	NS	*
SP × P	NS	NS	NS	NS	NS	NS	NS	NS
BG × P	NS	NS	NS	NS	*	NS	NS	*
SP × BG × P	NS	NS	NS	NS	NS	NS	NS	NS

^zValues are means of 252 observations for pruning and BA + GA₄₊₇ treatments and 168 observations for branch positions.

^yMeans within columns followed by the same letter do not differ significantly ($P = 0.05$), Tukey's HSD.

NS,*,** Not significant or significant at $P = 0.05$ and 0.01 , respectively.

Table 5. Effect of spur-pruning in 1986 and 1987, BA + GA₄₊₇ in 1986, and branch position on spur characteristics and fruit size of 'Fullred Delicious' trees in 1986.^{z,y}

Treatment	Position	Spur length (cm)	Bud diam (mm)	Leaf area/spur (cm ²)	Leaf dry wt/spur (g)	SLW (mg·cm ⁻²)	FW (g)	Fruit L:D
Nonpruned, no BA + GA ₄₊₇	Terminal	1.0 bc	3.4	117	1.9	8.1	102	0.98 abc
	Middle	1.5 abc	3.5	146	2.1	7.2	108	0.96 bc
	Basal	1.6 ab	3.5	139	1.8	6.5	120	1.00 abc
Nonpruned, BA + GA ₄₊₇	Terminal	0.9 c	3.6	104	1.8	8.7	100	1.01 abc
	Middle	1.6 ab	3.5	124	2.0	8.1	98	0.97 abc
	Basal	1.9 a	3.2	110	1.5	6.8	88	1.02 ab
Spur-pruned, no BA + GA ₄₊₇	Terminal	1.3 abc	3.7	122	2.1	8.6	123	0.94 c
	Middle	1.6 ab	4.0	161	2.7	8.4	132	0.95 bc
	Basal	1.5 abc	4.0	163	2.6	8.0	122	0.98 abc
Spur-pruned, BA + GA ₄₊₇	Terminal	1.5 abc	3.9	147	2.3	7.8	91	0.99 abc
	Middle	1.4 abc	3.8	141	2.1	7.4	97	1.00 abc
	Basal	1.0 bc	3.4	162	2.3	7.1	103	1.05 a
F test significance								
Spur-pruned (SP)		NS	**	**	**	*	NS	NS
BA + GA ₄₊₇ (BG)		NS	NS	NS	NS	NS	**	**
SP × BG		NS	NS	NS	NS	**	NS	**
Position (P)		*	NS	NS	NS	**	NS	**
SP × P		**	NS	NS	NS	NS	NS	NS
BG × P		NS	NS	NS	NS	NS	NS	NS
SP × BG × P		NS	NS	NS	NS	NS	NS	NS

^zValues are means of 14 observations.

^yFor variables with significant interactions, means within columns followed by the same letter do not differ significantly ($P = 0.05$), Tukey's HSD.

NS,*,** Not significant or significant at $P = 0.05$ and 0.01 , respectively.

terminal portion of spur-pruned branches and least at the basal portion of nonpruned branches (Table 6).

Discussion

The two strains of 'Delicious' responded similarly to pruning and BA + GA₄₊₇ treatments, but 'Starkrimson Delicious' generally responded to a greater extent, especially in 1987. The CD and YE in this study were less than typically reported (Lombard et al., 1988) for several reasons: 1) About one-third of the year following treatment (1987). For 'Starkrimson Delicious' in

secondary branches/scaffold branch was not used for data collection. 2) In 1986, the lower half of these trees was overthinned because the grower did not properly calibrate the sprayer. 3) Since these trees were old, the terminal portion of the scaffold branches and secondary branches had been repeatedly shortened

to prevent tree crowding. Although most spur quality characters in 1986 were improved by spur-pruning during the year of treatment (1986) in both experiments, most fruiting characters were not improved the

Table 6. Effect of spur-pruning in 1986 and 1987, BA + GA₄₊₇ in 1986, and branch position on spur characteristics of 'Fullred Delicious' trees in 1989.^{z,y}

Treatment	Position	Spur length (cm)	Bud diam (mm)	Leaves/spur	Leaf area/spur (cm ²)	Leaf dry wt/spur (g)	SLW (mg·cm ⁻²)
Nonpruned, no BA + GA ₄₊₇	Terminal	13.1	5.2 a	12.3	181	1.5 ab	8.2 a
	Middle	7.8	4.4 de	8.9	127	0.8 b	6.5 bc
	Basal	7.7	4.0 fg	9.5	113	0.6 b	5.3 c
Nonpruned, BA + GA ₄₊₇	Terminal	11.0	4.6 cd	11.4	150	1.2 b	7.8 a
	Middle	9.8	4.6 cd	9.6	123	0.8 b	6.6 b
	Basal	6.3	4.2 ef	8.7	115	0.7 b	5.8 bc
Pruned, no BA + GA ₄₊₇	Terminal	16.7	5.1 ab	12.8	234	2.0 a	8.2 a
	Middle	10.6	4.3 de	9.9	127	0.8 b	6.1 bc
	Basal	7.6	3.9 g	9.2	122	0.7 b	5.5 c
Pruned, BA + GA ₄₊₇	Terminal	16.6	4.8 bc	11.1	174	1.4 ab	7.9 a
	Middle	10.3	4.5 d	9.9	153	1.0 b	6.3 bc
	Basal	8.8	4.3 de	9.5	128	0.8 b	5.9 bc
F test significance							
Spur-pruned (SP)		**	NS	NS	*	NS	NS
BA + GA ₄₊₇ (BG)		NS	NS	NS	NS	NS	NS
SP × BG		NS	NS	NS	NS	NS	NS
Position (P)		**	**	**	**	**	**
BG × P		NS	NS	NS	NS	NS	NS
SP × P		NS	*	NS	NS	*	*
SP × BG × P		NS	NS	NS	NS	NS	NS

^zValues are means of 14 observations.

^yFor variables with significant interactions, means within columns followed by the same letter do not differ significantly ($P = 0.05$), Tukey's H_{SD} .

ns,*,** Not significant or significant at $P = 0.05$ and 0.01 , respectively.

1987, flowering was decreased, FS was increased, yield was decreased, and FW was not significantly affected by spur-pruning. For the more vigorous 'Fullred Delicious' in 1987, flowering was the only variable affected by spur-pruning. Since trees responded to spur-pruning only in the first year after treatment, spur-pruning is not a technique for long-term improvement of spur quality. Ferree and Forshey (1988) also failed to improve spur quality or fruit size by spur-pruning 25-year-old 'Starkrimson Delicious' or 13-year-old 'Redchief Delicious' scaffold branches. Removing 30% of each spur complex over entire 25-year-old 'Starkrimson Delicious' trees did not improve fruit size or leaf area per spur (Ferree et al., 1990). Perhaps removal of a greater portion of spurs than performed in this experiment would improve FW.

Application of BA + GA₄₊₇ reduced the YE and FS of 'Starkrimson' trees in 1986, but had little influence on spur or fruiting traits thereafter. Although BA was usually applied after bloom, when shoots were 2 to 5 cm long, to induce branching (Forshey, 1982), the application of BA + GA₄₊₇ at pink in this study increased spur length in 1986. Fruit set, but not flowering, was increased in 1987. Flowering (Roberts, 1952) and fruit set (Auchter and Schrader, 1923) were positively related to spur length. Fruit weight and seed number per fruit were negatively related to increasing concentrations of BA + GA₄₊₇ (Greene, 1984); the application of BA + GA₄₊₇ at bloom increased leaf area the year of treatment and reduced flowering the year after treatment (McLaughlin and Greene, 1984). Since the improved spur growth resulting from BA + GA₄₊₇ application did not influence flowering or FS the year following treatment, application of BA + GA₄₊₇ at pink does not appear useful for improving the fruiting characteristics of spur-bound 'Delicious' trees. BA + GA₄₊₇ increased the number of pygmy fruit, especially on nonspur-pruned branches. 2-(1-Naphthyl)acetic acid (NAA), which may induce pygmy fruit formation (Childers,

1980), was used to thin these trees. Since limbs not treated with BA + GA₄₊₇ produced few pygmy fruit in 1986, there maybe an interaction between BA + GA₄₊₇ and NAA. Results from apple thinning experiments in 1990 indicate that the combination of BA and NAA induces more pygmy fruit than NAA alone (unpublished data).

Canopy position had the greatest influence on spur characteristics. Terminal positions of 'Starkrimson Delicious' branches had spurs with the greatest leaf dry weight and SLW but the smallest fruit with the lowest L:D ratio. Although light was not measured in this study, spur characters appeared to follow the light distribution patterns reported for apple tree canopies (Porpiglia and Barden, 1980). Compared to spurs developing in shade, spurs in high light usually had greater leaf dry weight, SLW, bud diameter, spur length, and fruit size (Barritt et al., 1987; Ferree and Forshey, 1988). Fruit size did not follow the expected pattern in our study, possibly due to the interactions of spur-pruning × position and BA + GA₄₊₇ × position. Bud diameter and FW were significantly ($P \leq 0.05$) and linearly correlated with number of leaves per spur, leaf area per spur, and leaf dry weight per spur, but not SLW (data not presented), and spur-pruning improved leaf area per spur. Similar relationships have been previously reported, and SLW usually correlated well with FW (Barritt et al., 1987; Ferree and Forshey, 1988). However, in other studies FW was not related to percent full sun or SLW (Marini and Marini, 1986). Detailed spur-pruning, alone or in combination with BA + GA₄₊₇, does not seem adequate to improve FW on spur-bound 'Delicious' trees.

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