Journal American Pomological Society 55(3):166-172 2001

Influence of Four Apple Cultivars on Five Dwarfing Rootstocks on Spur Quality

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Abstract

Spur quality of four apple cultivars of varying growth habits on five dwarfing rootstocks was determined as an ancillary study on trees of the 1990 NC-140 cultivar-rootstock planting located in OH and KS. 'Empire' tended to produce more and smaller spur leaves, while 'Jonagold' tended to have fewer and larger spur leaves than other cultivars. The only interaction between cultivar and rootstock was bud diameter at both KS locations. The influence of rootstock on spur characteristics was small with the greatest effect on spur leaf area. Cultivar had a significant influence on most spur characteristics and confirms earlier work that scion is the major controller of growth distribution.

Previous work has shown a close relationship among spur quality characteristics and fruit size and calcium level (2,4). Long-term productivity of nine apple cultivars had a high correlation with spur leaf area and spur leaf size. (7). Spur quality as measured by increased leaf area, leaf size and specific leaf weight is higher in well illuminated areas of the canopy compared to shaded areas and thus, could be improved by cultural practices such as pruning and training (1,8). Both rootstock (9) and cultivar (3) have been shown to influence spur quality. The NC-140 1990 cultivar-rootstock planting provided a unique opportunity to determine the effects of five dwarfing rootstocks on four apple cultivar scions with differing growth habits on spur quality.

Materials and Methods

Four apple cultivars (Empire, Nicobel Jonagold, Smoothee Golden Delicious and Law Rome Beauty) on five dwarfing rootstocks (M.26 EMLA, O.3, M.9 EMLA, B.9 and MARK) were planted in 1990 in Wooster, Ohio, Manhattan, Kansas, and Wichita, Kansas as part of the NC-140 cultivar rootstock planting (6). Unfortunately, an epidemic of fireblight eliminated 'Rome Beauty' from the OH planting. The trees were planted 3 x 5.5 m, trained to a slender spindle with minimal pruning and staked. Pest and soil management were standard for each location.

In each year 1994 through 1996 a sample of five non-flowering single spurs were removed from two-year-old wood on the well exposed canopy periphery in August on five replicate trees of each combination. The number of leaves, leaf area, bud diameter at the widest point, and stem length of each spur was measured. Leaves were then dried at 70°C and dry weight determined for calculation of specific leaf weight. (SLW).

Results

Year had little effect on leaf characteristics of the spurs in Ohio, but the growth characteristics of bud diameter and stem length were lower in 1995 (Table 1). 'Empire' had more and smaller leaves that the other cultivars, but all cultivars had similar leaf areas. 'Golden Delicious' had smaller bud diameter and SLW compared to the other cultivars. Rootstock had no effect on leaf number, but spurs from trees on B.9 and MARK had a smaller leaf area due to smaller average leaf size.

In Manhattan, KS, spur leaf area, leaf size and SLW were small in 1996, which

Salaries and research support provided by state and federal funds appropriated to the Ohio Agricultural Research and Development Center, The Ohio State University. Received for publication 1/19/01. Manuscript number HCS 00-27.

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Table 1. Effect of year, cultivar, and rootstock on characteristics of 1-year-old nonflowering spurs, sampled from 2-year-old wood in late August, on apple trees planted in 1990 at Wooster, Ohio.

Year	Leaf No.	Leaf area (cm^2)	Leaf size (cm^2)	Bud diam. (mm)	Spur stem length (cm)	Specific leaf wt (mg/cm^2)
1994	6.39	70.50	11.20	3.47	1.49	11.35
1995	6.34	67.69	10.87	3.22	1.37	13.03
1996	6.40	72.73	11.75	3.41	1.42	11.49
LSD (P=0.05)	NS	NS	NS	0.09	0.06	0.41
Cultivar						
Empire	7.48	67.06	8.96	3.52	1.43	12.52
Jonagold	5.81	73.76	12.73	3.61	1.43	12.43
Golden Delicious	5.83	70.11	12.13	2.96	1.42	10.92
LSD (P=0.05)	0.17	NS	0.52	0.10	NS	0.49
Rootstock						
M.26EMLA	6.41	76.01	12.20	3.40	1.47	11.62
O.3	6.38	72.40	11.67	3.44	1.48	12.41
M.9EMLA	6.28	72.05	11.79	3.38	1.42	11.81
B.9	6.44	66.23	10.32	3.36	1.41	11.92
Mark	6.36	64.84	10.39	3.25	1.36	12.03
LSD (P=0.05)	NS	4.14	0.56	0.08	NS	NS
F Signigicance						
Year (Y)	NS	NS	NS	*	*	***
Cultivar (C)	***	NS	***	***	**	**
Rootstock (R)	NS	**	***	*	**	NS
Y x C	**	NS	NS	*	NS	NS
Yx R	NS	**	***	*	**	NS
R x C	NS	NS	NS	NS	NS	NS
Y x R x C	NS	*	**	***	NS	***

NS, *, **, *** Nonsignificant or significant at P≤0.05, 0.01, or 0.001, respectively

followed a year when spurs had a very small bud diameter and low leaf number (Table 2). 'Empire' had more leaves/spur than other cultivars and along with 'Rome Beauty' had small leaves resulting in a relatively small leaf area. 'Jonagold', the only triploid cultivars in the study, had very large leaves and had the highest leaf area and largest bud diameter of all cultivars.

Spurs from trees on M.26EMLA tended to have a large spur leaf area due to large leaf size and a relatively high number of leaves/spur, while spurs from trees on MARK had the reverse pattern. The larger trees on M.26EMLA and O.3 tended to result in spurs with larger bud diameter.

In Wichita, KS, spur bud diameter was also small in 1995, but there appeared to be no carry-over influence in 1996, as observed in the trees in Manhattan (Table 3). 'Empire' had more leaves/spur than other cultivars and along with 'Rome Beauty' had small leaves resulting in relatively small leaf areas. 'Jonagold' had few very large leaves/spur, which resulted in a large

Table 2. Effect of year, cultivar, and rootstock on characteristics of 1-year-old nonflowering spurs, sampled from 2-year-old wood in late August, on apple trees planted in 1990 at Manhattan, Kansas.

Year	Leaf No.	Leaf area (cm^2)	Leaf size (cm^2)	Bud diam. (mm)	Spur stem length (cm)	Specific leaf wt (mg/cm^2)
1994	5.43	58.44	10.97	4.06	1.68	11.59
1995	5.11	58.59	11.73	2.88	1.33	11.43
1996	5.60	50.78	9.13	3.81	1.20	10.77
LSD (P=0.05)	0.18	2.72	0.46	0.10	0.06	0.35
Cultivar						
Empire	5.71	55.53	9.88	3.74	1.42	11.92
Jonagold	4.80	61.13	12.72	3.91	1.39	11.58
Golden Delicious	5.14	54.16	10.78	3.16	1.33	10.55
Rome Beauty	4.88	52.93	9.06	3.52	1.47	10.99
LSD (P=0.05)	0.20	3.17	0.67	0.11	0.06	0.33
Rootstock						
M.26EMLA	5.60	61.61	11.25	3.66	1.46	11.14
O.3	5.53	58.28	10.81	3.65	1.43	11.41
M.9EMLA	5.33	53.66	10.23	3.54	1.38	11.22
B.9	5.33	57.03	10.97	3.55	1.42	11.16
Mark	5.13	49.11	9.78	3.50	1.32	11.38
LSD (P=0.05)	0.17	3.12	0.56	0.09	0.06	NS
F Signigicance						
Year (Y)	**	**	***	***	**	*
Cultivar (C)	***	*	***	***	**	***
Rootstock (R)	**	***	**	**	***	NS
Y x C	NS	**	***	NS	**	NS
Yx R	NS	NS	NS	***	NS	NS
R x C	NS	NS	NS	*	NS	NS
Y x R x C	NS	NS	*	**	NS	NS

NS, *, **, *** Nonsignificant or significant at P≤0.05, 0.01, or 0.001, respectively

spur leaf area which was accompanied by the largest spur bud diameter. Spur leaf area on trees on M.26EMLA was larger and on MARK smaller than on the other rootstocks. Trees on MARK and B.9 tended to have higher SLW's than on other rootstocks.

The only significant interactions between rootstock and cultivar for the spur characteristics occurred with bud diameter in the two KS locations. In Manhattan, spurs on 'Empire' trees on B.9 had smaller diameter spurs than O.3, while on 'Rome Beauty' the opposite was true (Fig. 1A). Spur diameter from trees on B.9 were smaller than on M.9EMLA with 'Empire' with the reverse true on 'Rome Beauty'with a similar trend in Wichita (Fig. 1B). Spur diameter of 'Jonagold' trees on B.9 and MARK were larger than on the larger rootstocks and this pattern was not present with the other cultivars.

Since this study had so many factors (locations, year, cultivar and rootstock) and

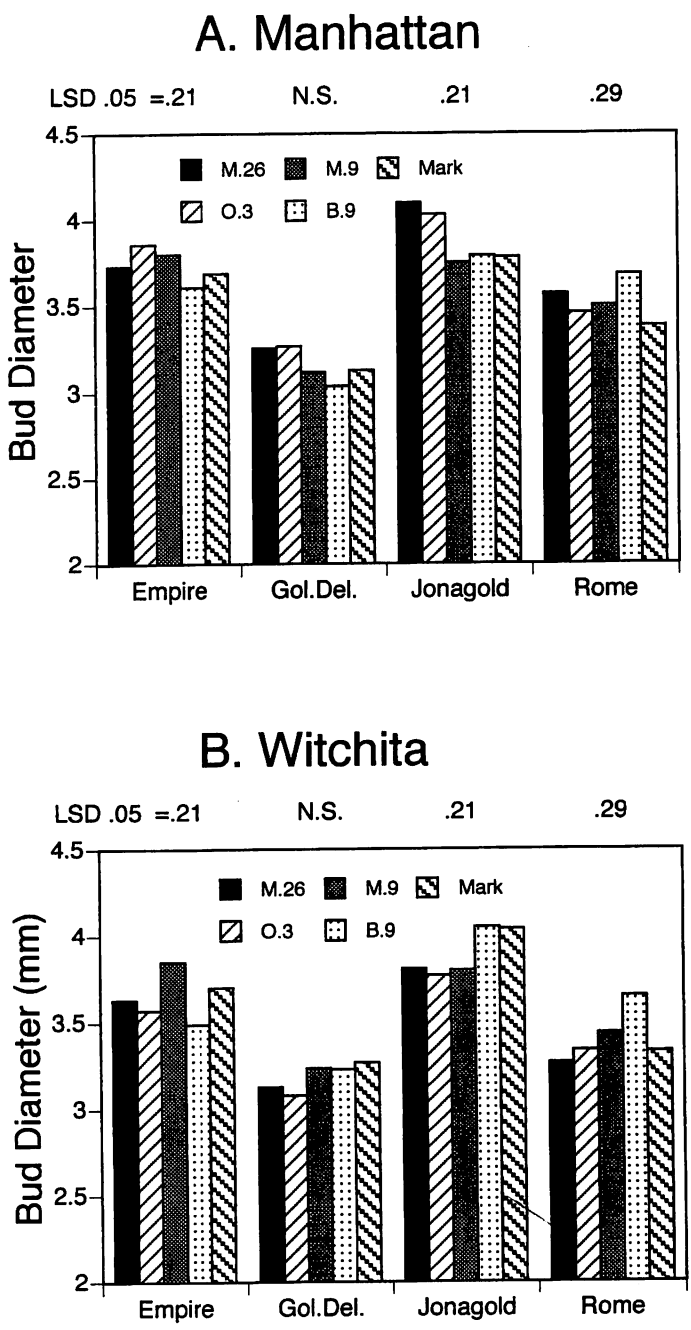

Figure 1. Interaction of four cultivars and five rootstocks on spur bud diameter in Manhattan (A) and Wichita (B), KS.

Table 3. Effect of year, cultivar, and rootstock on characteristics of 1-year-old nonflowering spurs, sampled from 2-year-old wood in late August, on apple trees planted in 1990 at Wichita, Kansas.

Year	Leaf No.	Leaf area (cm^2)	Leaf size (cm^2)	Bud diam. (mm)	Spur stem length (cm)	Specific leaf wt (mg/cm^2)
1994	5.59	53.44	9.91	4.33	1.58	12.22
1995	5.47	54.02	10.00	2.73	1.25	10.97
1996	5.79	58.32	10.15	3.54	1.34	11.33
LSD (P=0.05)	NS	NS	NS	0.25	0.07	0.29
Cultivar						
Empire	6.24	51.28	8.19	3.65	1.32	12.10
Jonagold	4.81	63.52	13.20	3.89	1.42	11.40
Golden Delicious	5.45	54.66	10.06	3.19	1.35	11.52
Rome Beauty	5.97	51.58	8.65	3.40	1.48	11.01
LSD (P=0.05)	0.23	3.28	0.43	0.18	0.06	0.34
Rootstock						
M.26EMLA	5.62	59.75	10.98	3.46	1.43	10.92
O.3	5.70	54.92	9.87	3.44	1.42	11.41
M.9EMLA	5.58	55.93	10.31	3.58	1.33	11.54
B.9	5.59	55.17	10.01	3.60	1.40	11.81
Mark	5.60	50.53	9.12	3.55	1.39	11.84
LSD (P=0.05)	NS	3.04	0.42	0.16	NS	0.34
F Signigicance						
Year (Y)	NS	NS	NS	***	NS	***
Cultivar (C)	***	***	***	***	**	**
Rootstock (R)	NS	**	***	*	NS	***
Y x C	*	*	***	***	NS	**
Yx R	**	NS	NS	*	NS	NS
R x C	NS	NS	NS	*	NS	NS
Y x R x C	*	NS	*	***	NS	*

NS, *, **, *** Nonsignificant or significant at P≤0.05, 0.01, or 0.001, respectively

their interactions that could influence the results, we calculated the percentage of the treatment sums of squares that were attributed to each (Table 4). Location accounted for more than half of the variation for spur leaf area, while year was the dominant factor for bud diameter and spur stem length. Although rootstock accounted for 10% of the variation in spur leaf area, it and all other factors were more influenced by cultivar.

Discussion

'Empire' had the most spur growth habit in this study, consistently had the most leaves per spur and the leaves tended to be small, and in the KS sites this resulted in small leaf areas. In a study comparing a wide range of cultivars, Rom and Ferree (7) found spur leaf area associated with fruit size and long-term yield. When spur leaf area was artificially manipulated on 'Golden Delicious' fruit size was positively re-

Table 4. Proportion (%) of total treatment variation of 1-year-old nonflowering spur variables attributed to the main effects of location, year, cultivar and rootstock and the interactions as determined by analysis of variance.

	Leaf No.	Leaf area (cm^2)	Leaf size (cm^2)	Bud diam. (mm)	Spur stem length (cm)	Specific leaf wt (mg/cm^2)
Location (L)	26.0***	52.6***	3.1*	10.6*	3.0	10.5*
Year (Y)	1.5*	0.3	2.9**	41.8***	77.1***	20.1***
Cultivar (C)	67.6***	26.0***	79.6***	49.9***	2.8	46.9***
Rootstock (R)	0.4	10.6***	3.9***	0.2	3.8***	2.9*
L x Y	0.3	2.9**	4.4***	3.5***	5.0***	21.8***
L x R	0.1	0.2	0.1	0.4***	0.3	0.4
L x C	2.1***	1.0	2.3***	0.1	1.5	4.0**
L x R x C	0.0	0.1	0.0	0.0	0.3	0.2
Y x R	0.3***	1.1***	0.5***	0.2**	0.9**	0.5
Y x C	0.6	2.6**	1.5***	1.0***	2.9**	1.7
Y x L x R	0.0	0.3**	0.1*	0.1***	0.1	0.2
Y x L x C	0.1	0.1**	0.7***	0.3***	0.8*	1.7**
Y x R x C	0.0	0.3	0.7***	0.1**	0.5***	0.3
R x C	0.1	0.2	0.1	0.2**	0.4	0.7
L x Y x R x C	0.0	0.1	0.5*	0.8***	0.0	0.2***

*, **, *** Significant at P≤0.05, 0.01, or 0.001, respectively

lated to spur leaf area (2). 'Empire' is well known to have small fruit size and small spur leaf area and leaf size may be factors that contribute to this characteristic.

'Jonagold' was the only triploid cultivar in this study and although not significant in all cases, it tended to have large spur leaves, spur leaf areas and fewer leaves than other cultivars. In a study comparing a range of cultivars in New Zealand, OH and ME, this same trend for 'Jonagold' existed (3). 'Jonagold' had relatively low seed counts at all sites and in spite of this had large fruit size. 'Jonagold' fruit size in this study was also large, particularly relative to 'Empire' and 'Golden Delicious'.

The effect of rootstock on the variables measured in this study was small. Spur leaf area was the character most affected by rootstock (10.6%, Table 4) and this characteristic was greatly affected by location and minimally by year. Ohio had much larger spur leaf areas than either of the KS locations for the three cultivars in common. In a previous study, New Zealand (NZ), OH and ME spur leaf areas of a wide range of apple cultivars was compared (3). 'Jonagold' tended to have one of the largest leaf areas in NZ and ME, but was smaller that 'Gala' in OH. Spur leaf area of 'Gala' was similar to 'Jonagold' in NZ and ME. 'Red Chief Delicious' had small spur leaf areas in all sites. Thus, it appears that the site-cultivar interaction for spur leaf area is not predictable.

Feucht (4) suggests that fruitfulness of apple was closely related to bud and spur quality and subsequent flower quality. Ferree et al. (3) found a strong correlation with the following flower characteristics and fruit set and fruit size for a range of apple cultivars at several sites: pedicel length, pedicel dry weight, flower dry weight. Several studies show that spur quality is closely associated with the light levels in the tree canopy with highest quality spurs are found in the best illuminated positions of the canopy (1,8). The effects of canopy light

environment in this study were minimized because spurs were chosen only on the well illuminated periphery of the canopy.

Warrington et al (9) in evaluating the influence of 9 rootstocks on spur quality of 'Delicious' found that spur leaf number and leaf area were highly correlated in vigorous rootstocks. They concluded that the most dwarfing rootstocks reduced both stem extension growth and the vigor of individual spurs. Their study included all the rootstocks in this study except B.9 and if just those rootstocks were compared, they found no difference in the various aspects of spur quality. Thus, the vigor relationship may apply only when rootstocks that produce trees larger than M.26EMLA are included.

Hirst and Ferree (5) reported that rootstock controls total growth, and scion mainly controls distribution of growth. Results of this study confirm that the scion cultivar had the major influence on most measures of spur quality. The only interaction between rootstock and cultivar that occurred was for bud diameter at the two sites in KS. Bud diameter has not been as closely related to fruit size, set and productivity as spur leaf area, spur leaf size and SLW (1,2,3,8).

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Journal American Pomological Society 55(3):172-177 2001

Wilder Silver Medal Recipients—1999 and 2000

The American Pomological Society (APS) is pleased to announce that Dr. John L. Maas and Dr. Silviero Sansavini were the recipients of the Wilder Silver Medal Awards for 1999 and 2000, respectively. The Wilder Medal was established in 1873 in honor of Marshall P. Wilder, the founder and first president of APS. The Wilder Medal is presented to individuals that have rendered outstanding service to horticulture in the area of pomology. Special consideration is given to work relating to the origination and introduction of meritorious fruit cultivars. In 1999, the Wilder Medal was presented to Dr. Maas at the annual meeting of the APS in Minneapolis, MN during the annual meeting of the American Society for Horticultural Science. In 2000, the Wilder Medal was presented to Dr. Sansavini (in absentia) at the annual meeting of the APS held in Orlando, FL during the annual meeting of the American Society for Horticultural Science.