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Spur Leaf and Flower Characteristics of Apple Cultivars in the 1995 NE-183 Trial

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Abstract

Apple spur samples were collected in July 1998 and 1999, or when the king flower was open in 2000 and 2001, and their characteristics were related to yield and fruit size. Spur characteristics of 'Braeburn', 'Golden Delicious' and 'Yataka' were similar on M.9 and Mark rootstocks. 'Braeburn' spurs had very small leaves and total leaf areas compared to most other cultivars. 'Cameo' and 'Fortune' tended to have large spur leaves in both years. Correlations between yield and fruit size showed no relationship with spur characters across this wide range of cultivars. Number of flowers per spur varied among cultivars and between years, but 'Rome Beauty' and 'Braeburn' tended to have more flowers and 'Cameo' fewer flowers then most other cultivars. 'Cameo' tended to have large king flower corolla diameter and long pedicels on both king and lateral flowers. Across these cultivars, pedicel length was positively correlated with fruit size. Pedicel length was positively correlated with spur leaf size and area in both years.

Introduction

Spur leaf area is strongly correlated to fruit set, fruit size and fruit Ca concentration at harvest (7,11), flower differentiation the following year (2), and long-term cumulative yield across a range of cultivars (13). Light environment appears to be closely associated with spur leaf area (1,3,12,14), and the cultural practice of pruning (6) and tree training systems (4) can alter spur quality. Wunsche and Lakso (17) reported that orchard yields were linearly and highly correlated (r^2=0.78) with spur light interception. Genetic characteristics of an apple tree can influence spur quality through the scion (9,14,16) or rootstock (9,16).

Over a range of apple cultivars, flower pedicel length and dry weight, as well as flower dry weight, were positively related to harvest fruit weight in New Zealand, Maine and Ohio (5). King and lateral pedicel length and dry weights were positively related to fruit set in New Zealand, but not in Maine or Ohio (5).

Since both spur and flower characteristics influence several important measures of apple production and tree efficiency, the 21 cultivars in the 1995 NE-183 trial were evaluated to determine the range of flower and spur sizes present.

Materials and Methods

On April 28, 1995, the NE-183 regional apple planting was planted in Wooster silt loam soil at the Ohio Agricultural Research and Development Center. Twenty-one cultivars were planted on M.9 T337 rootstock at a spacing of 2.5 x 4.5 m in north-south rows and supported by a 2 m post by each tree. In addition 'Braeburn', 'Golden Delicious' and 'Yataka' on Mark rootstock were included and all trees were minimally pruned and trained as central leaders. The cultivars were arranged as a randomized complete block with five replications.

In 1998 and 1999 a sample of five non-fruiting spurs was collected in mid-July from 2- or 3-year-old wood on each tree and the

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following measured: number of leaves, leaf area, and specific leaf weight. In 2000 and 2001 a sample of five spurs was taken when the king bloom was open and the following measurements taken: number of leaves, leaf area, number of flowers, diameter of corolla of king flower, weight of the king flower and pedicel length, weight and pedicel length of the lateral flowers, and number of bourse buds. These measurements were taken, due to time constraints, on 10 cultivars in the trial, plus a couple of standard cultivars. These data were collected in addition to the annual yield and growth measurements required by the NE-183 project.

Results and Discussion

Rootstocks M.9 and Mark did not differ in spur characteristics for the three cultivars compared (Table 1). An early trial found no differences in tree size, yield, or yield efficiency between Mark, M.9 or M.9EMLA (8,10,16) with 'Starkspur Delicious'. Similar results occurred with 'Lawspur Rome Beauty' or 'Red Chief Delicious', but 'Macspur McIntosh' trees were larger on M.9 than on Mark (8). 'Macspur McIntosh' trees on Mark had shorter shoots and fewer flowering spurs than trees on M.9. Among the 21 cultivars in the study spur leaf number ranged from 4.1 to 8.5. 'Braeburn' tended to have very small leaves and small total leaf areas in both years. This was also reported for 'Braeburn' trees grown in New Zealand, Maine and another study in Ohio (5). On average, spur leaf area was 30% greater in 1999 than in 1998 and this effect was consistent for all cultivars except 'Braeburn', 'Gala Supreme', and 'Ginger Gold' that had smaller spur leaf areas in 1999. Although 'Gala Supreme' and 'Ginger Gold' had relatively high yields, they were not higher than 'Golden Delicious', which had a 53% larger leaf area in1999 than in 1998 (data not presented). However, yields of 'Gala Supreme' and 'Ginger Gold' were higher in 1999 than yield of 'Golden Delicious'. Thus, spur leaf area may be reduced by crop load the years a heavy crop is present.

A comparison of the weather records indicate that April 1999 had 17% lower temperatures compared to the long-term average, and that solar radiation was 6% higher in April and 30% higher in May than the long-term average. The higher light levels may have accounted for the increased spur size as several studies show that spur leaf area follows canopy light levels (1,3,12,14). 'Cameo' and 'Fortune' tended to have large spur leaves in both years. There was a continuum of spur leaf area among these cultivars and relative rank changed each year.

Bourse leaf area is important to fruit size and quality of several apples cultivars (15). In 1999 the following cultivars averaged bourse shoots on more than 3 of 5 spurs per tree: 'Sansa', 'Golden Supreme', 'Ginger Gold', 'Gala Supreme', 'Golden Delicious' and 'Braeburn'. Most of the cultivars prone to bourse production had larger bourse leaf area than spur leaf area. In a study where spur complexes were purposely selected that had bourse shoots, bourse leaf area was consistently larger than spur leaf area for a wide range of cultivars (5).

The spur data collected at bloom (Tables 2 & 3) follow the pattern of the spurs collected in mid-July (Table 1) with 'Braeburn' having the smallest spurs. 'Rome Beauty' spurs taken from an adjacent orchard had a larger primary spur leaf area than cultivars in the NE-183 trial in 2000. 'Cameo' tended to have the largest spur leaf area in 1998, 2000, and 2001, although there was overlap with several cultivars. Both 'Rome Beauty' and 'Cameo' tend to be large-fruited cultivars and previous work has shown that within a cultivar, spur leaf area and fruit size are positively related (7), but the correlation among all the cultivars in this trial was not related (Table 4) as was found previously across cultivars (3).

Since spur leaf area is fully developed at or shortly after bloom, the areas in Tables 2 and 3 that were taken at bloom can be related to the mid-July sampled spurs in Table 1. Of the 6 cultivars sampled all four years, the largest spur leaf area occurred in 1999 for all except 'Braeburn'. Heavy crops on 'Enterprise' and 'Goldrush' in 2000 and 2001 may be related to the smaller leaf area, but the modest crop on 'Arlet' could not explain the small spur leaf area in 2000.

Number of flowers per spur varied among

Table 1. Spur characteristics of the cultivars in the 1995 NE-183 cooperative planting.

Cultivar/rootstock	1998			1999				
	Leaf number	Leaf area (cm^2) average	Leaf area (cm^2) total	Leaf number	Leaf area (cm^2) average	Leaf area (cm^2) total	Spurs with bourses	Bourse leaf area (cm^2)
Bracburn/M.9	7.5ab[z]	4.9f	37.2d	4.1g	3.1gh	13.0i	3.7	52.6bcdc
Braeburn/Mark	7.7a	5.5ef	42.7cd	4.1g	1.7h	7.1i	4.0	45.5bcd
Golden Delicious/M.9	5.7cdefg	9.1cd	51.1bcd	6.8bcde	1.0ab	108.5ab	----	----
Golden Delicious/Mark	4.8fg	9.4cd	45.7cd	6.0def	12.3abcde	79.6abcdefg	3.5	77.0abcd
Yataka/M.9	6.1cde	8.1cde	50.1cd	7.3abc	10.9bcdef	80.8abcdef	1.0	76.7abcd
Yataka/Mark	5.9cdefg	8.2cde	48.7cd	7.3abc	11.2bcdef	82.7abcdef	2.0	30.6ef
Arlet/M.9	5.7cdefg	8.8cd	50.3cd	7.1abcd	11.6bcdef	87.6abcde	2.5	55.4abcdc
Creston/M.9	5.4defg	9.8d	53.6bcd	6.1cde	14.8abc	93.8abcde	2.5	60.0abcde
Camco/M.9	5.5cdefg	13.7a	77.9a	6.3bcdc	14.5abc	92.0abcde	1.0	76.1abcdc
Enterprise/M.9	5.7cdefg	7.4cdef	42.4cd	6.6bcde	8.7def	58.6defghi	1.7	35.2def
Fuji (N-12)/M.9	5.8cdefg	7.6cdef	45.2cd	6.9bcd	10.6cdef	73.2bcdefgh	1.0	36.5cdef

Table 1 cont.

Gala Supreme/M.9	6.6abcd	7.2cdef	47.5cd	5.3efg	7.2fg	39.0hi	3.6	56.9abcde
Ginger Gold/M.9	5.7cdefg	7.6cdef	44.1cd	4.6fg	7.5efg	39.6ghi	3.7	65.0abcde
Golden Supreme/M.9	5.4cdefg	7.0def	38.0cd	6.3cde	10.0cdef	66.4cdefgh	3.5	60.9abcde
Goldrush/M.9	6.1cde	7.9cdef	47.7cd	6.0cdef	8.7def	56.2efgh	1.8	52.3bcde
Honeycrisp/M.9	6.5bcd	8.3cde	54.6bcd	7.9ab	11.0bcdef	88.0abcde	1.0	81.4abc
Fortune/M.9	6.8abc	12.7ab	87.0a	7.5abc	13.1abcd	99.9abcd	3.0	88.1ab
NY75414-1/M.9	4.6g	9.6cd	45.9cd	6.6bcde	9.4def	65.1cdefgh	2.0	70.4abcde
Orin/M.9	5.7cdefg	9.6cd	55.6bcd	7.3abc	13.4abcd	98.3abcd	2.0	----
Pristine/M.9	6.0cdef	7.9cdef	46.4cd	8.5a	10.6cdef	90.3abcde	2.0	64.abcde
Sansa/M.9	5.1efg	8.1cde	41.4cd	5.6def	7.2fg	43.9fghi	3.2	77.1abcd
Shizuka/M.9	4.6g	15.5a	71.6ab	5.6def	12.9abcd	75.1bcdefgh	3.0	86.7ab
Suncrisp/M.9	5.0efg	10.2bc	52.3bcd	6.1cde	16.9a	104.3abc	----	----
Sunrise/M.9	5.7cdefg	9.0cd	52.3bcd	6.6bcde	13.4abcd	89.1abcde	1.0	37.6cdef
Redfree/Mark	6.1cde	9.6cd	59.2bc	7.1abcd	16.6a	119.7a	1.0	98.6a

[z] Mean separation by Duncan's Multiple Range Test $P \leq 0.05$.

Table 2. Spur and flower characteristics of apple cultivars in 2000 in Wooster, Ohio.

	Spur				King flower				Lateral flower			
Cultivar	Leaf number	Area/ spur (cm^2)	Leaf size (cm^2)	Bourse number	Flowers/ spur	Corolla dia. (mm)	Dry wt. (g)	Pedicel length (mm)	Dry wt (g)	Pedicel length (mm)	Yield (kg)	Average fruit wt. (g)
Braeburn	7.20c	8.85g	1.22f	1.00a	5.8ab	33.4bcd	.22	10.4e	----	12.7f	49.8abc	203bcd
Golden Delicious	6.96cd	29.45cd	4.22c	.86ab	4.9d	38.4ab	.24	18.8b	.69cd	24.4b	32.9cde	340ab
Arlet	8.13ab	16.61f	2.03ef	18.9d	4.9cd	32.9bcd	.75	12.1de	C	18.9d	41.5bcd	178de
Cameo	8.46a	41.6b	4.89c	.73b	4.1e	39.5a	.31	27.5a	.86ab	29.0a	37.0bcde	230abc
Enterprise	6.63cd	25.42de	3.80cd	.93ab	5.0cd	37.5ab	1.34	16.0cd	.77bc	19.0d	81.7a	258a
Ginger Gold	6.0d	18.75ef	3.10de	1.00a	4.7d	35.4abc	.23	19.2b	.67c	21.5c	4.1e	238ab
Gold Rush	7.16c	17.33f	2.44e	.88ab	4.7d	31.1cd	.14	11.1e	.35d	13.8f	65.0ab	194cde
Pristine	8.05ab	17.08f	2.11ef	1.00a	5.0cd	33.5bcd	1.66	11.6e	C	12.9f	43.0bcd	138f
Sansa	4.63e	35.47bc	7.73a	1.00a	4.6d	30.4d	.21	12.0de	.78bc	16.0e	8.1de	161ef
Suncrisp	7.00c	30.02cd	4.15c	.75b	4.7d	33.6bcd	.20	13.9d	.62c	18.9d	71.2ab	210bcd
Redfree	7.36vd	29.90cd	3.97cd	1.06a	5.4bc	34.5bcd	.24	11.8e	.86ab	12.9f	16.5cde	160ef
Rome Beauty*	8.43a	55.3a	6.46b	1.06a	6.0a	33.8bcd	.23	18.9b	.97a	23.7b	----	----

*Collected from an orchard adjacent to the NE-183 planting.

Table 3. Spur and flower characteristics of apple cultivars in 2001 in Wooster, Ohio

Cultivar	Leaves	Leaf area/ spur	Bourses	Flowers/ spur	King flower			Lateral Flower			Yield (kg)	Average fruit wt. g
					Corolla dia.	Dry wt.	Pedicel length (mm)	Total wt. (g)	Average wt. (g)	Pedicel length (mm)		
Braeburn	6.9cd[z]	13.3f	1.00bc	5.3ab	23.2d	.10i	9.9ef	.43cd	.10e	12.0f	62.2	181cde
Golden Delicious	6.5d	27.6bcd	.56c	4.7cd	32.4a	.21bc	19.2a	.70a	.19b	21.4a	32.0	210bcd
Arlet	8.4a	31.6abc	1.04b	5.0bc	28.8bc	.19bcd	14.8bc	.69a	.17bc	186bc	45.5	180cde
Creston	6.8cd	35.1ab	.75bcde	4.4d	28.3bc	.26a	14.7bc	.68ab	.28ab	17.3cd	27.4	261a
Cameo	6.8cd	37.8a	.65de	4.3d	33.3a	.25a	19.0a	.73a	.22a	23.0a	45.8	202bcde
Enterprise	5.6e	16.8ef	.68cde	5.7a	27.9bc	.16def	9.9ef	.67ab	.14cd	11.3f	44.4	220bc
Fuji	6.6cd	22.5cdef	.68cde	4.6cd	29.0bc	.15efg	15.4bc	.52cd	.14cd	14.8de	75.6	163c
Goldrush	7.5abc	22.3cdef	.88bcde	5.0bc	22.8d	.10hi	11.0de	.39d	.10e	12.5ef	27.9	172de
Honeycrisp	7.9ab	15.4ef	1.72a	4.9bc	22.9d	.13gh	7.8f	.43cd	.11e	10.1f	28.2	234ab
Sansa	7.1bcd	21.3def	.76bcde	4.3d	30.4ab	.18cd	11.6de	.52cd	.15cd	12.1f	----	----
Rome Beauty[y]	6.5d	29.0abcd	.96bcd	5.5a	33.2a	.17de	16.1b	.74a	.16bc	20.8ab	C-	----
Red Chief[y]	7.3bcd	23.6cde	.84bcde	4.3d	33.1a	.21b	15.8bc	.55bc	.17bc	15.6d	----	----
Gala[y]	8.0ab	24.3cde	.88bcde	5.3ab	26.2c	.14fg	13.4cd	.51cd	.12de	15.0de	----	----

[z]Mean separation within columns by Duncan=s multiple range test, $P \leq 0.05$

[y]Collected from orchards adjacent to the NE-183 planting.

Table 4. Correlation coefficients of spur and flower characteristics with yield and fruit size of the 21 cultivars in the NE-183 cooperative cultivar planting. (Coefficients based on 2000 data in standard type, coefficients based on 2001 data in bold type).

	Yield	Avg. wt.	Leaf #	Leaf size	Leaf area	Flower #	King dia.	King wt.	King pedicel	Lat. wt.	Lat. pedicel	Bourse
Yield	---	**-.29**	**-.19**	**-.03**	**-.11**	**.07**	**-.00**	**-.13**	**.12**	**-.05**	**.02**	**-.01**
Avg. Wt.	.37**[z]	---	**-.21**	**.07**	**-.04**	**.02**	**-.02**	**.36**	**-.25**	**.22**	**-.13**	**.01**
Leaf #	.26	-.06	---	**-.05**	**.27***	**-.03**	**-.12**	**-.07**	**-.02**	**-.12**	**.03**	**.43****
Leaf size	-.27	-.-2	-.27	---	**.94****	**-.15**	**.53****	**.66****	**.67****	**.68****	**.76****	**.31****
Leaf area	-.14	.10	.21	.85**	---	**-.14**	**.47****	**.60****	**.64****	**.62****	**.75****	**-.17**
Fl. #	.00	-.30*	.24	-.10	.05	---	**-.28***	**-.43****	**-.26***	**.19**	**-.08**	**.18**
King Dia.	-.13	.44**	.15	-.02	.13	-.20	---	**.74*8**	**.71****	**.60****	**.67****	**-.53*8**
King wt.	.23	.04	.16	-.10	-.06	-.07	.05	---	**.67****	**.69****	**.65****	**-.29****
King pedicel	-.07	.56**	.29*	.32*	.54**	-.37**	.58*8	-.02	---	**.58****	**.88****	**-.43***
Lat. wt.	-.27	.01	.18	.53**	.65**	.46**	.30	.05	.32*	---	**.74****	**-.16**
Lat. pedicel	-.05	.56**	.28	.38**	.59**	-.31*	.48**	-.03	.91**	.41**	---	**-.26***
Bourse	-.12	-.44**	-.05	.02	-.01	.30*	-.32*	.00	-.29**	.15	-.25	---

[z]Coefficient significant at $P \leq .05$ (*) or $P \leq .01$ (**).

cultivars and between years, but 'Rome Beauty' and 'Braeburn' tended to have more flowers and 'Cameo' fewer than most other cultivars. 'Cameo' with few flowers and relatively large spur leaf area tended to have large king flower corolla diameter and long pedicels on both king and lateral flowers. 'Braeburn' tended to have short pedicels, but a continuum existed among cultivars. Previous work (5) has shown that flower pedicel length was related to fruit size and this was confirmed in the present study in 2000 with significant correlations for both king and lateral pedicel length with average fruit weight (Table 4).

King flower pedicel length and dry weight were correlated with leaf size and leaf area in both years (Table 4). A negative relationship existed between bourse number and king flower diameter and pedicel length. King flower pedicel length and diameter were positively related to lateral flower weight and pedicel length. Yield was not correlated to any of the spur or flower characters measured indicating the many complex factors that determine yield.

In summary, spur characters did not have a close relationship to yield or fruit size in this diverse group of cultivars. The flower characteristics of corolla diameter, pedicel length and sometimes flower dry weight appeared related to fruit size.

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