

Performance of Apple Cultivars in the 1995 NE-183 Regional Project Planting: I Growth and Yield Characteristics

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Abstract

A multi-site experiment to evaluate the performance of apple cultivars was established in 1995 with twenty different cultivars. The purpose of the experiment was to evaluate new and promising apple cultivars in a range of geographical and climatic areas within North America. All trees were propagated on M.9 and minimally pruned to encourage early bearing. At the end of the fifth growing season 'Shizuka' were the largest trees, and had the highest yields. 'Honeycrisp' and 'Braeburn' were among the smallest trees and had low cumulative yields. 'Gala Supreme', 'Golden Supreme' and 'Pristine' were among the least yield efficient. Across all sites, 'Fortune', 'Golden Supreme', 'Pristine', 'Suncrisp' and 'Yataka' had biennial bearing indices (BI) that suggested that they were more prone to biennial bearing. 'GoldRush' had the highest cumulative yield efficiency and cumulative crop load of all the cultivars tested. 'Arlet' had the highest mean number of fruit per year, while the largest fruit were produced by 'Shizuka'. 'Pristine' and 'Golden Supreme' had high levels of preharvest fruit drop. Days from full bloom to harvest varied depending upon cultivar with 'Pristine' maturing first and 'GoldRush' last. A stability analysis was performed for all variable measured. No cultivar proved perfectly stable. However, 'Fuji' had the fewest significant stability variances while 'Honeycrisp' had the most significant variances.

Introduction

Apple production in the United States is a strong and viable industry producing a crop value of over U.S. \$1.6 billion annually. Much of the recent growth and economic viability of this industry has been based upon the development of cultivars for new and traditional markets. In 1990 cultivars such as 'Fuji', 'Gala' and 'Braeburn' accounted for less than one percent of production in either the European Union or the United States. In 2002-03 it was estimated that they accounted for 15% of the EU crop and 21% of the U.S. crop. O'Rourke (7) predicts that by 2010, excluding China, 'Gala' will be the third largest cultivar in the world after 'Delicious' and 'Golden Delicious'. Increasingly the U.S. is competing with foreign producers. Chile, Brazil, South Africa, New Zealand, the European Economic Union, and eastern European countries all impact the market price

and sale of apples in the United States and export markets. In order to stay competitive it is important to rapidly deploy new and viable apple cultivars.

In 1994 a cooperative multi-state research project (NE-183) was initiated to evaluate horticultural qualities and pest susceptibility of new apple cultivars, strains, and advanced selections at numerous locations throughout the United States and Canada to determine both the limitations and positive attributes. When the cultivars were initially chosen for this trial they were believed to be potentially promising or unique. In the interim and based largely on the work performed by this group we have learned that some are not as promising as thought. This project is the first comprehensive work on uniformly evaluating apple cultivars in the United States across a range of growing conditions. It is hoped that commercial fruit growers can utilize the

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data on tree performance to evaluate how the cultivars might perform in their region.

This article reports the horticultural characteristics of the trees and yields of the first cooperative planting established in 1995. Fruit quality results can be found in a previous paper (6)

Materials and Methods

Greene (4) previously described the cultivars in this test. Pictures and descriptions of the cultivars are also available at the NE-183 web site at <http://ne183.org>. Four cultivars possess the *V_r* gene for apple scab (*Venturia inaequalis* (Cooke) G. Wint., anamorph *Spilosea pome Fr.*) resistance: 'Pristine', 'Enterprise', 'GoldRush' and NY75414-1. Fourteen of the cultivars were from breeding programs and six were chance seedlings. In spring 1995 a multi-cultivar planting was established at 17 different sites in the United States and Canada (Table 1). Trees were propagated on virus free Malling 9 rootstock by Adams County Nursery (Aspers, Pennsylvania) and distributed to the cooperators in March 1995. 'Golden Delicious' (Gibson strain) was chosen as a standard for comparison. Trees were planted

in a randomized complete design with three to five replications at a spacing of 2.5 x 4.3 m. Guard trees were placed at the end of each row. Site and soil preparation, fertilization and pest control were according to local recommendations and need. All trees were supported. Tree training was done according to commercial practices, with the general goal of a pyramid-shaped canopy and minimal pruning in the first two years. All fruit that developed in the year of planting were removed. In the second year, blossom clusters were counted with a local option to leave or remove fruit. Fruit were thinned to a spacing of 15-20 cm. The date when 90% of spur flowers were in full bloom was recorded.

Trunk cross-sectional area (TCSA) was calculated from trunk circumference measured at 30 cm above the graft union at the end of each growing season. Tree height and spread were measured in the fall of 2000. Spread was determined by averaging the in-row and cross-row spread of the trees. The height to spread ratio (H:S) was calculated from the individual tree measurements.

The goal of the cooperators was to harvest fruit when the starch index rating ranged between 4 and 6 based on the Cornell Generic

Table 1. Locations, cooperators and percent tree survival of the 1995 NE-183 apple cultivar planting.

Fayetteville, AR	AR	C Rom	88
Summerland, British Columbia	BC	C Hampson	98
Amherst, MA	MA	D. Greene	98
Monmouth, ME	ME	J. Schupp/R. Moran	84
Pitstown, NJ	NJ	R. Belding/W. Cowgill	96
Highland, NY	NYH	E. Stover/D. Rosenberger/J. Schupp	100
Geneva, NY	NYG	S. Brown	99
Ithaca, NY	NYI	I. Merwin	99
Fletcher, NC	NC	J. D. Obermiller	94
Wooster, OH	OH	D. Miller/D. Ferree	95
Simcoe, ON	ON	J. Cline	92
Corvallis, OR	OR	A. Azarenko	95
Biglerville, PA	PAB	G. Greene II	97
Rock Springs, PA	PAR	R. Crassweller	100
Burlington, VT	VT	E. Garcia/L. Berkett	98
Wenatchee, WA	WA	B. Barritt	83
Madison, WI	WI	T. Roper	100
Kearneysville, WV	WV	S. Miller	61
	WVD		95

Starch-Iodine Index Chart (1). At harvest, fruit number (NF) and weight were determined for each tree. In the first two years of cropping dropped fruit were counted and weighed. In the last two years, dropped fruit were counted but not weighed. Adjusted fruit yield was determined by adding the weight of drops and picked fruit in the first two years. In the last two years the weight of the number of dropped fruit was multiplied by the average weight of the fruit that was harvested. The mean number of dropped fruit (DF) and percent dropped fruit were calculated for each tree from the yearly data. The cumulative yield (CY) for each cultivar was then determined by computing the sum of all the annual yields. Average fruit weight (FW) was the yearly yield divided by the number of fruit per tree. Crop load (CL) was the mean number of fruit divided by the annual TCSA. Cumulative yield efficiency (CYE) was determined by taking the CY and dividing by the TCSA for the year 2000. A biennial bearing index (BI) based on Hoblyn et al. (5) was determined utilizing the number of fruit per tree each year.

Response variables were analyzed with the MIXED procedure of the SAS statistical software package (Ver. 8 - Release 8.02, SAS Institute Inc., Cary, NC). Factors used in specifying model effects were cultivar, location, block (of the randomized block design), and year (when yearly data rather than averages or totals over years were analyzed). For data resulting from averaging or totaling over years for each tree, the model included the fixed effects of cultivar and the random effects of location, cultivar x location, and block nested within location. For data from yearly observations, this same model was used with the addition of three types of random effects: those for block x cultivar nested within location, those for year nested within location and those for cultivar x year nested within location. In this model, the residual is block x year nested within location and cultivar. In both models, the variance of the cultivar x location effects was allowed to differ among cultivars; thus, there was one interaction variance for each cultivar and these are the stability variances whose interpretations are described below (9). The Satterthwaite option (Ver. 8-Release 8.02; SAS Institute Inc., Cary, NC) was used for determining the

degrees of freedom.

The overall objective of the analysis was to compare cultivars across locations, with respect to their means across locations and the consistency of their differences from location to location. The former was done by comparing the cultivar generalized least squares means using pair-wise multiple t-tests, each at the 5% probability level. The main source of random error in these comparisons is the random cultivar x location interaction effects. To accomplish the latter, each cultivar had its own variance component for its interaction effects with locations, which is called the stability variance. A stable cultivar is one whose stability variance is zero, indicating that all its interaction effects with the locations are zero. This would mean that its mean in a given location differs from the mean of all cultivars in that location by an amount that is the same for all locations. Therefore, a stable cultivar is one whose means for a population of locations parallels the means of all cultivars in those locations. Significance of a stability variance estimate was obtained by a one-tailed test based on a normal approximation and tests the hypothesis that the cultivar's stability variance is equal to zero.

Results and Discussion

Tree Survival

Table 1 lists the cooperators and the sites where the trees were planted. The planting sites were geographically dispersed across the United States and Canada and represent all the major apple producing areas. Some states had multiple sites as indicated by the addition of a third letter to the state code abbreviation. Tree survival was generally very good. The exception was the one WV site where the majority of the trees were lost in the year of planting due to fire blight. (*Erwinia amylovora* (Burrill) Winslow et al.).

Tree Size

Tree size, as measured by TCSA, was smallest for 'Braeburn' and largest for 'Shizuka' (Table 2). 'Shizuka' is a triploid and was approximately 35% larger than the standard of 'Golden Delicious'. 'Arlet', 'Enterprise' and 'Pristine' were the next largest trees but were not significantly different from 'Shizuka'. 'Fortune' and 'Fuji' had a

Table 2. Trunk cross sectional area and stability variance and tree height, spread and height to spread ratio of 20 apple cultivars in the 1995 NE-183 apple planting.

Cultivar	TCSA (cm ²)		Stability variance	Tree height (m)		Tree spread (m)		Height:spread ratio	
Arlet	34.3	ab ^z	10.0	3.19	ab	2.59	cde	1.27	bcde
Braeburn	14.3	j	25.1^y	2.49	h	1.96	i	1.36	ab
Cameo	30.3	cd	2.1	2.99	bcde	2.58	cde	1.20	cdefg
Creston	25.4	g	9.5	2.65	gh	2.35	g	1.18	defgh
Enterprise	33.9	abc	67.7	3.00	cde	2.74	abcd	1.12	ghi
Fortune	30.0	cdf	0.0	2.97	cde	2.76	ab	1.13	ghi
Fuji	30.0	cd	0.0	2.93	de	2.79	ab	1.08	i
Gala Supreme	30.2	cde	6.0	3.11	abc	2.72	abcd	1.18	efgh
Ginger Gold	27.5	efg	9.8	3.00	bcde	2.81	a	1.11	hi
Golden Delicious	27.7	eg	3.6	2.90	def	2.52	ef	1.21	cdef
Golden Supreme	31.9	bc	3.7	3.18	a	2.72	abc	1.22	cdef
GoldRush	21.8	h	7.4	2.89	ef	2.16	hi	1.40	a
Honeycrisp	15.5	ij	46.4	2.58	h	2.09	hi	1.29	bcd
NY75414-1	18.2	i	13.2	2.96	cde	2.39	fg	1.32	abc
Orin	27.7	deg	10.0	3.00	cde	2.21	ghi	1.40	a
Pristine	35.0	ab	40.5	2.92	def	2.64	bcde	1.15	fghi
Shizuka	38.3	a	81.1	2.98	cde	2.78	abcd	1.14	fghi
Suncrisp	25.1	g	17.9	2.95	cdef	2.24	gh	1.35	ab
Sunrise	27.5	eg	2.1	3.07	abcd	2.53	ef	1.26	bcde
Yataka	25.4	g	9.0	2.79	fg	2.58	de	1.13	fghi

^zMean of 15 locations. Those sharing a common letter within each column are not significantly different by a t test at the 5% significance level.

^y Stability variances printed in bold typeface are significantly different from zero

Table 3. Cumulative yield (CY), yield efficiency (CYE), mean number of fruit per year, biennial bearing index (BI) and the associated stability variances for 20 apple cultivars in the 1995 NE-183 apple planting

Cultivar	CY		Stability	CYE		Stability	Mean no.		Stability	BI		Stability
	(kg)		variance ^z	kg/cm ²		variance	fruit/year		variance			variance
Arlet	57.5	ab	139	1.84	fgh	0.11	123.6	a	1820	0.36	f	0.003
Braeburn	32.5	fg	10	2.32	abc	0.32	54.3	g	0	0.46	cdef	0.023
Cameo	53.8	ab	42	1.93	defg	0.01	93.9	cd	80	0.55	abcde	0.023
Creston	41.9	cde	73	1.81	efgh	0.15	67.3	fg	149	0.54	bcde	0.006
Enterprise	58.9	ab	418	1.98	cdefgh	0.21	77.4	ef	439	0.39	f	0.001
Fortune	46.9	bcd	337	1.63	hi	0.28	62.4	fg	437	0.69	a	0.045
Fuji	56.4	ab	35	2.14	bcd	0.13	107.3	ab	39	0.59	ab	0.011
Gala Supreme	37.6	cdefg	137	1.31	ij	0.18	63.1	fg	178	0.57	abc	0.007
Ginger Gold	54.7	ab	79	2.33	abc	0.33	99.5	abcd	326	0.45	def	0.016
Golden Delicious	55.1	ab	42	2.28	bc	0.07	109.1	abc	511	0.50	bcde	0.010
Golden Supreme	38.5	de	8	1.30	j	0.00	73.8	f	140	0.61	ab	0.016
GoldRush	57.0	ab	148	2.73	a	0.33	113.2	ab	779	0.56	abcd	0.013
Honeycrisp	30.1	g	82	2.07	bcdef	0.23	52.4	g	379	0.58	abc	0.016
NY75414-1	36.3	efg	11	2.15	bcde	0.14	90.6	de	180	0.39	f	0.019
Orin	42.6	cde	115	1.74	gh	0.07	93.2	cde	272	0.54	bcde	0.010
Pristine	41.3	cdefg	369	1.15	j	0.34	112.9	abcde	4298	0.61	abcd	0.049
Shizuka	64.3	a	367	1.90	defgh	0.16	93.4	bcde	419	0.53	bcde	0.018
Suncrisp	55.5	ab	214	2.49	ab	0.67	90.6	de	155	0.61	abc	0.044
Sunrise	44.7	c	15	1.95	defg	0.10	107.5	abcd	884	0.43	ef	0.022
Yataka	36.7	def	12	1.68	h	0.03	75.7	f	105	0.66	a	0.017

^zMean of 15 locations. Those sharing a common letter within each column are not significantly different by a t test at the 5% significance level.

^y Stability variances printed in bold typeface are significantly different from zero

zero stability variance for TCSA indicating they performed similarly across all sites. Six cultivars had stability variances that were significantly different from zero indicating that their tree size, was influenced by location. Trees of 'Golden Supreme' and 'Arlet' were the tallest but were not significantly different from 'Sunrise' and 'Gala Supreme'. 'Braeburn' and 'Honeycrisp' trees were the shortest trees. 'Ginger Gold' had the greatest spread after five years but not significantly greater than many of the other cultivars. 'Braeburn' had the least spread. Seven cultivars had an average tree spread that was less than the in row spacing of 2.5 m; five had a spread approximately equal to the in-row spacing and the remainder exceeded the spacing and undoubtedly required containment pruning. The H:S ratio gives an estimate of the overall shape of the tree canopy with a higher number indicating a tree that is taller than it is wide. Trees that have a naturally wider spread will need to be planted further apart in the row and rows may need to be wider apart for trees that are taller. 'Orin' and 'GoldRush' exhibited the greatest H:S ratio, while 'Fuji' trees tended to have a wider canopy relative to tree height.

Yield

'Shizuka' had the greatest CY although numerous other cultivars, including 'Golden Delicious', were not significantly lower (Table 3). 'Honeycrisp' had the lowest CY but not significantly less than four other cultivars. Twelve cultivars had a stability variance for CY that was significantly different from zero indicating CY varied by site for those cultivars. 'GoldRush' had the highest CYE but it was not significantly different from that of 'Suncrisp', 'Ginger Gold' or 'Braeburn'. 'Pristine', 'Golden Supreme' and 'Gala Supreme' had the lowest CYE. The high CYE for Braeburn was most likely due to the smaller tree size since CY and NF were low compared to most other cultivars. In contrast 'Golden Supreme' and 'Gala Supreme' had low CYE, which was affected by having low CY and NF values.

'Arlet', had the greatest mean NF per year, although five other cultivars were not significantly different (Table 3). 'Honeycrisp' and 'Braeburn' trees averaged the least NF but not significantly less than 'Creston', 'Fortune' or 'Gala Supreme'. 'Braeburn'

had a zero stability variance for NF which suggests it consistently produced fewer fruit within each site. Eight cultivars had a stability variance that was significantly different from zero suggesting that these cultivars produced inconsistent numbers of fruit.

The biennial bearing index (BI) is important to determine in new cultivars so appropriate steps can be taken by commercial growers to adequately thin the fruit. Examples in the literature (8) suggest that values above 0.6 indicate strong biennial bearing. 'Fortune', 'Yataka', 'Golden Supreme', 'Pristine' and 'Suncrisp' all had BI values above 0.6 indicating a stronger tendency towards alternate bearing. 'Cameo', 'Fuji', 'Gala Supreme', 'GoldRush' and 'Honeycrisp' however, did not have BI that was significantly different from cultivars having a BI above 0.6. 'Cultivars with low BI were 'Arlet', 'Enterprise', and NY75414-1, indicating that they tend to have a crop each year. Eleven cultivars had stability variances that were significantly different from zero. Having that many of the cultivars with significant stability variances may suggest that during the course of the experiment crop load adjustment was not uniform across all sites or that some sites were more prone to loss of crop due to frost.

'Shizuka' and 'Fortune' had the greatest average FW (Table 4), while fruit from 'Pristine' and NY75414-1 were the smallest. These rankings were similar to the results from Miller et al.(6) in which a ten apple sample was used as an estimate of fruit weight. Overall the values for the mean FW of the whole crop were slightly smaller than those derived from a 10 fruit sample. However, in many cases the difference was minimal. Nine of the twenty cultivars had a stability variance for FW that was significantly different from zero. Similar to the results from Miller et al. (6) cultivars that had large fruit size were unstable for this trait. Since fruit size is strongly influenced by crop load, the stability variance in FW may be a reflection of differences in crop adjustment. It is interesting to note that 'Shizuka' had the highest CY, a medium to low NF per tree, but the FW was not stable.

'GoldRush', NY75414-1 and 'Sunrise' had the highest average crop loads (CL). 'Gala Supreme' had the lowest CL but not significantly lower than four other cultivars.

Table 4. Average fruit weight, crop load (fruit/cm² TCSA), mean number of drops per tree and percent fruit drop in relation to number of fruit harvested for 20 apple cultivars in the 1995 NE-183 apple planting

Cultivar	Average fruit weight (g)	Stability variance	Crop load #fruit/TCSA	Stability variance	# Drops	Stability variance	% Drop [*]
Arlet	178.8 i ^z	108	4.59 cdegh	0.6	17.6 abc	1.84	12.9 bcd
Braeburn	198.8 fgh	403 ^y	4.51 efgh	0.7	7.0 efg	2.32	10.7 cdefg
Cameo	238.6 cdef	7456	4.46 egh	0.9	7.6 efg	1.93	6.9 efg
Creston	232.7 d	552	3.89 h	2.0	6.2 efg	1.81	8.4 cdefg
Enterprise	264.2 bc	890	3.10 ij	0.5	7.0 efg	1.98	9.2 def
Fortune	289.0 ab	1059	2.81 ij	0.1	12.6 bcde	1.63	14.9 abcd
Fuji	204.0 fg	182	5.11 cdf	0.0	5.8 fgh	2.14	5.8 fgh
Gala Supreme	227.7 d	571	2.70 j	0.5	2.9 h	1.31	5.0 gh
Ginger Gold	221.3 de	312	4.97 bcdeg	0.7	6.3 efg	2.33	5.6 g
Golden Delicious	195.4 gh	146	5.22 bcd	2.1	10.5 cdef	2.28	9.9 de
Golden Supreme	209.3 ef	83	2.86 ij	0.5	23.3 ab	1.30	22.9 ab
GoldRush	186.3 hi	360	6.51 a	1.2	4.9 gh	2.73	2.9 h
Honeycrisp	225.9 d	389	4.29 gh	0.6	8.6 def	2.07	13.2 bcd
NY75414-1	149.2 k	160	5.86 ab	0.3	17.2 b	2.15	14.1 bc
Orin	176.1 i	34	4.52 egh	0.6	8.3 def	1.74	8.8 defg
Pristine	143.3 k	80	4.04 degghi	0.13	29.2 a	1.15	22.8 a
Shizuka	290.3 a	581	3.19 ij	4.8	14.0 bcd	1.90	12.5 bcd
Suncrisp	216.8 de	22	5.13 bcde	0.0	9.12 def	2.49	9.1 cdefg
Sunrise	163.0 j	75	5.60 abc	1.1	8.0 efg	1.95	6.4 efg
Yataka	187.3 hi	106	4.57 deggh	2.2	5.7 efgh	1.68	4.7 gh

^z Means of 15 locations. Those sharing common letter within each column are not significantly different by a t test at the 5% significance level

^y Stability variances printed in bold typeface are significantly different from zero by a one-sided z test at the 5% significance level.

^{*} All stability variances were significantly different from zero by a one-sided z test at the 5% significance level.

Table 5. Day of full bloom, days from full bloom to harvest and day of harvest for 20 cultivars of apples in the 1995 NE-183 apple planting.

Cultivar	Mean calendar day of full bloom	Mean days from full bloom to harvest	Mean calendar day of harvest
Arlet	118.5 h ^z	126.5 j	247.3 j
Braeburn	119.9 fg	168.0 b	289.7 b
Cameo	122.6 ab	159.5 d	283.7 cd
Creston	120.5 f	143.7 i	267.5 h
Enterprise	122.0 bcd	163.4 c	286.2 c
Fortune	121.8 cd	150.9 ef	275.8 f
Fuji	121.6 d	166.1 bc	289.7 b
Gala Supreme	122.8 ab	155.0 de	277.4 ef
Ginger Gold	120.3 f	113.2 k	234.8 k
Golden Delicious	122.4 bc	147.7 gh	271.9 g
Golden Supreme	123.4 abc	124.7 j	251.3 l
GoldRush	120.8 ef	176.9 a	297.0 a
Honeycrisp	122.8 abcd	124.7 J	250.3 i
NY75414-1	119.5 g	145.0 hi	265.2 h
Orin	119.0 gh	157.8 d	279.1 e
Pristine	119.2 g	91.5 m	214.1 m
Shizuka	121.5 de	149.5 fg	272.4 g
Suncrisp	123.3 a	158.8 d	283.2 d
Sunrise	119.1 g	104.0 l	224.7 l
Yataka	120.4 f	148.1 fghi	271.0 g

^z Means of 15 locations. Those sharing a common letter are not significantly different by a t test at the 5% level of significance.

None of the mean CL values would be considered excessive (2). 'Fuji' and 'Suncrisp' had stability variances of zero indicating their relative rank in comparison to the other cultivars in these plantings was stable.

The number of fruit that drop (DF) prematurely can have an economic impact on the profitability of a cultivar and may pose problems in timing harvest. In most cases this was achieved with the exception of 'Yataka'. Most cooperators never managed to harvest fruit within the 4 to 6 range of starch ratings (6). 'Pristine' had the highest average number of fruit to drop followed by 'Golden Supreme' and 'Arlet'. 'Gala Supreme' had the lowest average number of fruit that dropped followed by 'GoldRush', 'Yataka' and 'Fuji'. Seven cultivars had stability variances for FD that

were significantly greater than zero including 'Pristine.' This suggests that while 'Pristine' had the highest average FD across all sites it did not perform in the same manner in all sites.

Bloom and Days to Harvest

'Arlet' and 'Orin' were generally the earliest blooming cultivars in the trial while 'Suncrisp' tended to be the latest blooming (Table 5). There was an approximately six day average difference in full bloom between the earliest and latest blooming cultivars. As expected the mean days from bloom to harvest varied by cultivar. 'Pristine' was the first cultivar to ripen followed by 'Sunrise'. The latest maturing cultivar was 'GoldRush'. All the stability variances for bloom, harvest date and days from harvest to bloom were significant

indicating that the stability of these data varied with each site. The range in days from bloom to harvest for most cultivars was broad. In general however, the northern sites had shorter bloom to harvest periods while the southern sites had longer periods (Table 6).

Cultivar evaluation can be somewhat subjective and what appears to perform well in one region may not perform well in another (3). However, when the authors met in 1999 we discussed the pros and cons of the cultivars as they appeared in each planting. An informal poll was taken among the members as to their views on whether a particular cultivar was promising based upon the results to date. Cultivars that received a clear majority of favorable votes included 'Cameo', 'Fuji', 'Ginger Gold', 'Golden Supreme', 'Honeycrisp', 'Shizuka', 'Sun crisp' and 'Yataka'. Those cultivars that were not viewed favorably were: 'Braeburn', 'Creston', 'Gala Supreme', 'NY-75414-1' and 'Orin'.

No cultivar was perfectly stable. However, 'Fuji' had the fewest significant stability variances and 'Honeycrisp' had the most. Variables for which most cultivars had significant stability variances were CY, CYE, BI, and percent fruit drop. The most stable variables measured were tree height, spread and height:spread ratio. 'Fortune', 'GoldRush' and 'Honeycrisp' had stability variances that were significantly different from zero for CY, NF, FW and CYE suggesting that for the cultivars in these plantings their yield parameters were heavily influenced by location. Growing cultivars such as these therefore might be very dependent upon the site chosen or upon the ability of the grower to properly manage the cultivar.

There is no information in the literature comparing the yields of the cultivars planted in this study. Cumulative yield, however, should not be the sole criterion for choosing a cultivar. It is clear that no one parameter can be used to judge the value of a new cultivar. For example, 'Braeburn' had a low CY; but because it was

a small tree a high CYE. 'Braeburn' also had low NF and low BI suggesting that this cultivar had a small crop every year. 'Honeycrisp' had low CY but because of the smaller tree size had a higher CYE but the mean NF was low and BI was high suggesting the cultivar was biennial. Therefore, 'Honeycrisp' most likely had a small crop but did not necessarily fruit each year. Parameters such as biennial bearing, fruit size and overall fruit quality impact upon the selection of a cultivar. The consistency of the performance of a cultivar is also important and those cultivars that have consistently high quality traits are the most desirable. What was not studied in this experiment was the monetary return between different cultivars. A cultivar that has a slightly lower cumulative yield may be more valuable if there is a monetary premium associated with its sale.

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Table 6. Mean days from full bloom to harvest by location for 20 apple cultivars in the 1995 NE-183 apple planting

Cultivar	AR	BC	MA	ME	NC	NJ	NYH	NYI	ON	PAB	PAR	VT	WI	WV	Range ^z
Arllet	121	136	122	122	122	132	127	123	.	122	122	122	123	127	121-136
Braeburn	182	174	159	153	175	182	171	166	157	162	165	151	145	167	145-182
Cameo	151	161	154	145	173	173	145	158	.	153	153	143	.	165	143-173
Creston	136	147	136	146	140	166	132	133	138	134	119	141	137	.	119-166
Enterprise	155	173	159	148	158	172	162	164	155	166	167	148	157	173	148-173
Fortune	153	162	148	137	152	159	145	151	128	147	155	145	145	150	128-162
Fuji BC#2	179	162	158	143	176	178	172	167	161	165	165	148	153	170	143-179
Gala Supreme	163	149	156	138	146	161	160	164	143	165	159	143	142	164	138-165
Ginger Gold	115	123	105	116	113	109	102	108	105	112	109	108	111	118	102-118
Golden Delicious	147	148	143	140	153	151	148	153	140	146	142	141	140	148	140-153
Golden Supreme	123	134	116	131	114	115	121	118	112	126	119	122	122	130	114-126
GoldRush	178	178	164	.	183	197	170	173	159	183	173	151	157	190	151-197
Honeycrisp	122	129	113	118	120	136	131	121	133	122	114	108	122	124	108-136
NY75414-1	163	155	135	135	140	155	142	141	129	143	147	134	133	149	129-163
Orin	148	162	150	143	160	182	146	159	144	157	159	140	133	166	133-166
Pristine	98	94	85	87	89	91	84	89	87	92	82	.	89	97	84-98
Shizuka	148	151	141	138	141	163	140	155	145	148	137	157	143	.	137-163
Suncrisp	151	162	153	145	155	169	152	160	160	157	155	157	141	175	141-175
Sunrise	106	109	99	110	98	110	86	102	111	104	97	98	101	107	86-111
Yataka	139	140	138	138	136	160	150	136	160	138	142	150	136	161	136-161

^zRange represents the earliest and latest mean days from bloom to harvest across all locations.