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Fruit Varieties Journal 50(1):11-18 1996

Performance of the NC-140 Cooperative Apple Rootstock Planting II: A 10-Year Summary of TCA, Yield and Yield Efficiency at 31 Sites

NC-140[1]

Abstract

In 1984 trees of 'Starkspur Supreme Delicious' apple (*Malus x domestica* Borkh) on 15 rootstocks were planted at 31 sites in North America according to guidelines established for cooperative testing by the North Central Regional Cooperative Project (NC-140). Six midwestern sites lost 20% or more of the trees over 10 years, while 13 sites had less than 10% loss. The following rootstocks had 60% or higher losses at one or more sites: MAC.39, P.22, M.4, M.26EMLA, P.2, P.16, P.18, C6. B.9 had the best survival of the dwarfing rootstocks in this study with no losses at 14 sites. Sites in KS, GA, IL, CA, VA, MO, NC, and MI had trees with 39 to 16% larger than average trunk cross-sectional area (TCA), while trees in TN, PA, and MEX were 40% smaller than the average of all sites. Averaged across rootstocks, sites with the greatest yield efficiency were MA, CA, OH, and BRC and those with lowest efficiency were KS, TN, MN, NY, AR and NC.

Evaluations of potential apple rootstock and interstem systems have been made independently by researchers at many locations. Lack of common genetic materials, spacings, and handling procedures have made comparison of the results from these independent studies difficult. Because of lack of information, growers have planted many scion/rootstock combinations at inappropriate spacings for their soils or that were poorly adapted to their area. Extension recommendations often vary widely from region to region with little understanding among professional horticulturists for the differences.

[1]Authors listed in Table 1, page 7, FVJ 50(1):1996.

Salaries and research support provided by state and federal funds appropriated to the Ohio Agricultural Research and Development Center, The Ohio State University, Journal Article No. Appreciation is extended to Oregon Rootstock Inc., Woodburn, OR 97071 for propagating and donating trees for the planting and to the International Dwarf Fruit Tree Association for shipping expenses. Special thanks are extended to Bert Bishop, Ohio State University for performing the statistical analyses of the data.

Cooperative plantings organized by NC-140 were designed to solve these problems and also dramatically shorten the time required to test new rootstock candidates. The wide diversity of climatic and soil conditions at NC-140 sites expose scion/rootstock combinations to a wide range of conditions.

Results of earlier NC-140 cooperative plantings have been published (1, 2, 3, 4, 5, 6). The test plantings reported here were established in 1984 to compare performance of 15 different rootstocks with a common scion cultivar, 'Starkspur Supreme Delicious,' at 31 sites in North America. Plantings in QUE and TX were removed prior to the conclusion of the study.

Materials and Methods

The coldest temperature recorded was -32.2°C in IA in 1985 (Table 1). IA had the coldest temperature in 4 of the 10 years of the trial. Readers are referred to the paper by Warmund et al. (7) that describes black-heart and winter injury symptoms from several of those trials. The warmest winters occurred in 1987 and 1992 when minimums at the coldest sites were only -22°C. Generally the coldest winter was 1985 when 7 sites had minimums of -28°C or lower. The maximum temperature over the period of this study was 44.9°C in CA in 1986. CA had the highest maximum temperature in 4 of the 10 years. Severe droughts occurred in 1988 and 1993 in the east and Midwest, and 19 sites had maximum temperatures above 37°C when normally only 4-8 sites exceeded this temperature. The coolest growing season was 1987 when no site exceeded 30°C.

Results and Discussion

The cooperators and sites as well as the experimental design and data collected were described in the previous paper (4). The relative performance among sites will be compared in this paper. Past studies (2, 3, 6) and grower experience indicate that survival is a very important factor in assessing the potential of a new rootstock. Six midwestern sites lost 20% or more of the trees in this study over 10 years, while 13 sites had less than 10% loss (Table 1). Sites in the west and northwest (CA, OR, WA, UT, BRC) generally had very low tree losses of 6% or less. These sites were all irrigated which may have contributed to improved tree survival. The following rootstocks had 60% or higher losses at one or more sites (MAC.39, P.22, M.4, M.26-EMLA, P.2, P.16, P.18, and C6). Survival of the following rootstocks was 70% or greater in all sites: MAC.1, M.7EMLA, B.490, and A.313. The rootstocks P.1, SDL, and P.18 would have fallen into this desirable classification except for losses at one site. Of the rootstocks producing trees of M.26 size or smaller, B.9 had the best survival with no losses reported for 14 sites and KS reported the highest loss of B.9 (50%). This record is compared to P.22, the rootstock with the greatest losses, having no losses at only 5 sites and more than 50% loss at 8 sites.

Based on TCA, sites in KS, GA, IL, CA, VA, MO, NC, and MI had trees 39 to 16% larger than average, while trees in TN, PA and MEX were 40% smaller than the average over all sites (Table 3). Trunk cross-sectional area for KS and GA likely are inflated because those sites had only a partial planting and did not include several of the smaller rootstocks. KS also reported significant crop loss in 3 years due to frost which stimulated vegetative growth. However, these sites also produced large trees in previous studies (1). As in previous studies, the CA site was obviously stressful, either due to heavy crop loads or high temperatures, to rootstocks producing small trees and was very stimulating to such rootstocks as M.4, P.18, A.313 resulting in large trees. CA, GA, VA, and NC have relatively long growing seasons and along with sites in KS and IL have reported large tree size in previous

Table 1. Yearly maximum and minimum temperatures (°C) at the sites for the 1984 NC-140 apple rootstock trial.

	1984		1985		1986		1987		1988		1989		1990		1991		1992		1993	
	max	min	max	min	max	min	max	min	max	min	max	min	max	min	max	min	max	min	max	min
AR	40.0	-22.0	39.4	-25.5	43.0	-18.0	27.0	-11.0	38.0	-25.0	37.0	-17.0	32.3	- 4.0	32.7	- 7.2	32.7	-11.1	37.8	-16.1
BRC	37.0	-21.0	36.5	-23.0	34.0	-17.5	37.0	-11.0	35.0	-16.0	33.0	-17.5	37.0	-26.0	34.0	-16.0	37.0	-16.0	33.0	-16.0
CA	36.7	- 1.1	42.2	- 2.2	44.9	- 0.5	27.0	- 4.0	34.0	- 1.0	30.6	- 5.0	41.0	- 8.0	42.0	- 5.0	41.0	- 2.0	40.0	- 3.0
CO	35.0	-22.0	37.0	-24.0	36.7	-14.4	34.0	-17.0	37.0	-23.0	39.0	-28.0	38.0	-27.0	37.2	-19.0	36.0	-20.0	35.4	-14.1
GA	32.2	-17.2	32.7	-17.2	36.1	-18.9	26.0	-10.0	35.0	-17.0	32.0	-21.0	35.0	-12.0	33.0	-16.0	32.0	-14.0	36.0	-22.0
IL	35.0	-26.7	33.9	-31.1	35.0	-21.1	26.0	-12.0	39.0	-23.0	---	-29.0	36.0	-22.0	38.0	-22.0	35.1	-21.7	34.4	-22.8
IN	---	-16.7	33.0	-31.1	34.0	-22.0	24.8	- 9.4	30.1	-22.6	34.7	-21.5	34.1	-29.7	35.8	-18.7	35.2	-22.6	32.0	-22.0
IA	36.7	-30.6	38.3	-32.2	32.8	-27.2	16.1	-16.7	38.9	-30.0	36.5	-30.6	36.1	-26.7	36.7	-27.8	33.9	-22.8	31.7	-28.4
KS	41.0	-23.0	40.0	-25.0	39.0	-18.0	41.9	-11.6	35.0	- 9.0	40.7	-31.2	47.3	-22.0	41.0	-21.0	35.6	-16.1	38.9	-20.6
KY	37.0	-26.0	34.0	-27.0	38.0	-19.0	27.8	-12.2	39.4	-17.0	31.1	-25.6	38.3	-17.8	38.3	-12.7	35.0	-15.0	37.8	-16.1
MA	35.0	-27.2	31.1	-22.2	32.8	-20.6	23.0	-19.0	37.0	-30.0	34.0	-21.0	33.0	-18.0	39.0	-15.0	32.0	-21.0	36.0	-22.0
ME	---	-23.6	35.2	-27.6	33.7	-24.2				-18.0	26.7	-22.7	33.4	-22.5	36.2	-20.4	33.5	-23.7	34.5	-31.7
MEX	---	- 3.5	31.5	-11.0	32.5	-12.0	35.0	-12.5	31.0	- 8.9	35.0	- 8.9	40.0	-10.0	41.0	- 9.0	44.0	- 6.0	44.0	- 6.0
MI	32.2	-25.0	33.0	-21.0	32.0	-21.0	24.0	-20.0	38.0	-26.0	33.0	-22.0	31.0	-11.0	33.0	-16.0	35.0	-19.0	33.0	-20.0
MN	34.0	-32.7	38.0	-32.0	34.8	-29.7	37.0	-12.0	40.0	-28.0	36.0	-27.0	29.0	-29.0	31.0	-30.0	25.6	-16.1	30.0	-27.8
MO	40.0	-23.3	35.6	-26.1	37.2	-20.0	25.6	-15.6	40.0	-30.0	37.2	-10.6	37.2	-17.8	39.4	-20.6	33.9	-13.3	35.0	-19.4
NC	35.0	-12.3	34.7	-26.9	36.0	-19.0	23.0	- 7.0	36.0	-20.0	33.0	- 8.0	33.0	-11.0	39.0	-16.0	32.0	-12.0	36.7	-18.3
NJ	21.7	-27.7	28.3	-25.7	35.6	-13.3	25.6	-12.8	37.8	-19.4	35.0	-15.0	35.9	-12.7	37.2	- 9.8	33.5	-14.5	37.3	-17.2
NOS	19.5	-19.0	31.0	-23.0	31.5	-21.0	14.5	-22.0	33.0	-23.5	32.5	-21.0	32.5	-27.0	37.0	-23.6	30.0	-18.0	33.0	-30.0
NY	32.8	-23.8	31.7	-23.2	31.7	-18.9	33.3	-25.0	36.1	-21.1	31.7	-24.4	35.0	-19.4	35.0	-20.6	29.0	-19.0	35.0	-22.0
OH	31.1	-26.7	35.6	-28.3	33.3	-18.3	26.0	-12.0	40.0	-21.0	35.3	-27.5	34.1	-36.8	36.5	-19.1	32.5	-19.6	36.1	-20.0
OR	35.8	- 8.4	36.5	-10.5	35.0	- 4.0	10.5	- 4.5	41.0	- 7.0	34.0	-14.0	38.0	-14.4	36.7	- 7.2	29.7	- 6.0	37.2	-12.2
ONT	---	- 4.2	25.7	-11.2	33.0	-23.6	35.0	-23.5	36.3	-20.7	32.6	-20.2	31.9	-18.1	33.2	-20.3	29.9	-21.0	33.3	-18.7
PA	32.8	-24.4	35.0	-27.2	32.8	-17.8	24.0	-11.0	39.0	-23.0	37.0	-23.0	33.0	-20.0	35.0	-20.0	32.0	-20.0	34.0	-20.0
QUE	30.5	-20.0	30.0	-28.0	29.0	-27.3				-15.0	31.1	-27.0	31.0	-21.0	31.0	-21.0				
TN	33.0	-24.0	34.0	-32.0	33.9	-21.7	26.0	- 9.0	38.0	-18.0	29.0	- 3.0	29.0	-17.0	35.0	-23.0	32.0	-18.0	36.7	-16.7
TX			40.6	-12.7			30.0	- 5.0	39.0	-10.0	38.0	-22.0	38.0	- 4.0						
UT	37.2	-22.2	38.3	-21.7	41.0	-12.0	35.0	-14.0	38.0	-15.0	39.0	-14.3	39.0	-25.6	36.7	-17.0	38.3	-15.6	36.1	-18.3
VA	32.2	-19.4	32.2	-22.0	33.0	-23.0	18.0	-18.0	36.0	-19.0	31.0	-23.0	33.0	-14.0	33.3	-16.7	32.2	-13.9	34.0	-16.0
WA	39.7	-20.0	39.4	-21.7	39.4	-15.0	19.0	-13.0	40.0	-17.0	41.0	-13.0	41.0	-29.0	38.0	-18.0	40.0	-14.0	37.0	-21.0
WI	32.0	-30.0	32.0	-30.0	33.8	-22.7	30.0	-12.2	37.2	-23.9	33.8	-23.3	33.8	-24.4	33.8	-25.0	31.6	-22.2	30.0	-21.1
WV	25.0	- 8.3	35.0	-26.1	36.7	-16.2	26.0	-12.0	40.0	-21.0	35.0	-20.0	37.0	-15.0	39.0	-18.0	35.0	-16.0	39.0	-18.0

Table 2. Tree loss (%) over 10 years of 'Starkspur Supreme Delicious' on 15 rootstocks at 30 sites in the NC-140 planting established in 1984.

Site	SDL	P.18	A.313	B.490	MAC.1	M.4	M.7E	P.1	M.26E	C6	MAC.39	B.9	P.2	P.16	P.22	% loss
AR	0*	0	10	0	0	0	0	0	0	20	0	0	20	16	40	6.6
BRC	0	0	20	0	0	0	0	0	10	30	0	0	30	10	0	6.6
CA	0	0	10	0	0	0	0	0	0	0	10	0	0	10	20	3.3
CO	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
GA	30	--	--	--	0	50	10	0	20	--	40	0	--	--	100	16.6
IA	0	0	0	0	0	0	0	0	0	0	0	0	30	10	20	4.0
IL	0	0	0	0	0	0	0	0	0	30	60	0	30	50	30	13.3
IN	0	0	10	0	0	0	0	0	60	60	70	30	50	90	40	27.3
KS	0	--	--	--	0	0	10	10	10	--	50	50	--	--	70	22.2
KY	0	--	--	--	10	10	0	20	10	--	30	30	--	--	60	20.0
MA	0	10	0	0	0	0	10	0	10	10	0	0	10	20	0	4.6
ME	0	--	0	0	0	--	30	0	0	30	90	0	60	--	40	20.8
MEX	0	--	--	--	20	0	0	40	0	--	0	40	--	--	50	16.6
MI	10	0	0	0	0	10	0	10	0	50	0	0	20	30	20	10.0
MN	10	10	0	10	30	60	30	0	30	50	60	30	70	30	50	31.3
MO	40	--	--	--	10	20	30	20	50	--	70	30	--	--	60	36.6
NC	0	0	10	0	10	10	0	0	30	40	80	10	50	10	40	19.3
NJ	0	0	0	0	0	0	0	10	0	--	0	40	--	--	70	13.3
NOS	0	--	--	--	0	0	0	0	0	0	0	10	0	0	10	2.2
NY	0	0	0	0	0	0	10	10	10	10	40	10	50	40	30	14.0
OH	0	10	0	0	0	0	0	0	0	20	0	0	20	20	10	5.3
ONT	0	--	--	--	0	0	0	0	0	--	0	0	--	--	20	1.3
OR	0	0	10	0	0	0	0	0	0	10	0	0	10	10	20	4.0
PA	0	30	20	0	0	10	10	0	0	30	20	20	10	30	0	12.0
TN	20	--	--	--	10	10	0	10	50	--	40	30	--	--	70	26.6
UT	0	0	0	0	0	0	0	0	0	20	0	0	10	0	0	2.0
VA	10	90	30	0	10	0	0	10	0	10	0	0	10	30	10	14.0
WA	0	0	0	0	0	0	0	0	0	0	0	10	20	10	20	4.0
WI	10	0	20	0	0	0	0	10	0	20	0	0	40	20	10	8.6
WV	0	--	--	--	0	0	0	0	0	--	30	10	--	--	30	7.7
Avg.	4.3	7.5	7.0	.1	3.3	6.3	3.6	5.0	9.6	20.5	20.0	11.6	24.0	31.5	30.0	

*0 = no loss, -- = trees not included.

trials (1, 3). As in a previous study (1), the CA site had the highest absolute variability relative to the mean as measured by coefficient of variation (CV). KY, ME, MN, and MEX had relatively low C.V. values. Nine of the sites had relatively low LSD values (less than 20), while 4 sites had LSD values above 40.

Averaged over all rootstocks, the CA site had the highest yields and on rootstocks producing trees larger than M.7, had yields double or greater than the average over all sites (Table 4). CA also had high variability as evaluated by LSD or C.V. OH, VA, GA, and IL had relatively high average yields per tree, while the following sites had relatively low yields compared to the average over all sites: TN, MN, NY and AR. Sites with higher yields tended to have higher variability, while sites with low yields tended to have low variabilities. B.9, the dwarfing rootstock with the best survival, had higher than average yields in 7 sites, average yields in 15 sites and below average yields in 6 sites. Variation across sites for B.9, as measured by LSD and CV, was relatively low compared to a number of the rootstocks producing larger trees. P.18, which showed some yield

Table 3. Trunk cross-sectional area (cm²) after 10 years of 'Starkspur Supreme Delicious' on 15 rootstocks in the 1984 NC-140 trial.

Site	SDL	P.18	A.313	B.490	MAC.1	M.4	M.7E	P.1	M.26E	C6	MAC.39	B.9	P.2	P.16	P.22	Avg.	LSD .05	C.V.
AR	132.0	150.9	154.7	124.0	113.4	123.0	102.9	107.1	93.7	88.7	70.4	36.8	25.7	23.5	12.7	90.6	17.8	51.6
BRC	115.8	106.0	84.9	116.7	107.6	106.6	58.0	79.6	78.0	74.8	51.0	32.9	41.5	30.8	28.6	74.2	16.7	48.2
CA	218.0	295.7	239.4	200.9	158.8	270.0	81.0	96.3	90.0	38.4	45.5	16.9	18.4	13.6	12.2	119.7	39.1	84.8
CO	137.3	134.8	125.0	109.2	130.2	120.0	81.8		58.4	69.6	46.5	33.5	61.0	38.8	15.3			
GA	245.3				228.9	210.5	132.1	114.8	78.3		58.6	68.4				142.1	50.4	53.2
IA	174.3	179.6	171.2	135.7	151.8	148.3	96.9	114.5	84.1	59.1	57.8	33.2	30.8	19.2	12.5	97.9	13.7	61.3
IL	206.1	203.6	202.8	201.3	202.9	191.7	126.0	123.6	110.2	65.3	66.2	38.9	31.9	23.0	11.2	120.3	43.7	63.4
IN	175.7	188.4	179.7	157.8	146.7	141.2	100.1	94.9	74.8	50.6	38.8	24.5	24.2	9.6	9.9	94.5	22.8	69.7
KS	224.4				250.4	296.7	148.4	202.2	125.3		68.7	30.9			30.2	153.0	41.3	63.4
KY	137.2				132.6	141.0	107.7	76.6	105.9		85.0	77.2			34.6	99.8	33.9	35.0
MA	124.2	130.0	127.2	113.0	113.6	91.5	65.8	64.8	39.5	38.6	34.3	24.8	20.0	8.2	8.5	66.9	19.5	61.2
ME	61.6		90.0	89.6	70.0		50.5	48.9	36.2	27.6	14.7	23.8	16.6		4.7	44.0	13.2	33.8
MEX	82.9				40.2	55.4	60.5	69.5	64.4		36.9	64.8			27.5	55.8	15.8	31.6
MI	205.6	200.2	192.2	166.5	159.6	172.2	125.8	133.0	85.2	77.4	57.9	31.7	24.4	18.2	13.3	111.0	23.5	63.8
MN	105.9	120.0	116.1	10.83	126.4	28.2	79.3	87.2	81.6	85.2	53.2	50.5	64.7	65.5	52.6	81.7	31.6	35.8
MO	171.3				162.5	156.7	81.0	132.4	41.4	67.6	86.4	25.7			25.7	114.7	44.2	60.3
NC	138.4	127.3	115.8	168.0	131.6	141.5	118.5	74.0	87.1	65.9	100.5	68.5	45.0		68.9	112.9	NS	46.8
NJ	138.0				136.4	118.2	95.6	86.5	71.1		38.3	20.2			9.2	79.3	20.2	68.9
NOS	118.1				147.2	100.7	95.0	91.2	64.9		34.1	30.5			7.6	76.6	12.6	59.5
NY	141.6	177.1	171.5	160.0	146.5	112.6	85.7	55.9	47.7	46.9	39.0	27.9	22.9	10.9	8.3	83.6	20.5	73.9
OH	169.0	155.5	157.3	135.4	136.0	119.9	104.8	103.6	80.5	84.2	56.5	49.6	31.7	18.2	26.6	95.3	22.1	52.9
ONT	143.9				121.2	120.3	85.9	105.6	77.5		55.2	38.0			12.0	84.4	18.3	51.1
OR	136.5	168.3	150.1	153.9	132.6	130.2	95.0	118.0	103.2	76.8	66.0	43.6	27.0	27.1	16.4	96.3	18.1	52.6
PA	85.6	107.3	77.3	79.7	98.6	71.5	64.1	58.0	47.8	37.5	39.7	31.3	18.0	10.1	8.6	55.7	16.4	56.2
TN	73.5				78.2	63.7	72.8	49.5	37.0		40.7	34.1			12.7	51.1	18.1	43.3
UT	162.8	180.2	178.7	138.3	162.5	156.7	81.0	132.4	41.4	67.6	86.4	25.7	19.1	15.1	16.1	97.6	25.4	65.6
VA	210.7	147.1	202.9	201.7	187.2	185.8	127.0	103.2	115.4	80.3	81.0	43.9	34.1	18.3	18.3	117.1	33.8	59.6
WA	139.8	155.2	142.6	138.0	119.5	125.7	99.5	105.5	37.9	41.7	34.3	33.1	31.0	11.9	12.6	81.9	19.0	65.4
WI	134.9	158.8	139.3	147.4	97.8	102.1	74.1	78.4	74.8	62.9	35.7	45.5	27.8	18.0	11.0	80.6	21.7	60.1
WV	157.1				154.8	148.4	121.1	124.8	102.8		59.7	50.2			35.6	106.1	21.9	44.1
Avg.	152.4	164.0	155.8	147.0	142.4	138.7	102.7	98.3	77.2	63.4	54.7	41.1	29.9	20.1	20.1			
LSD	37.6	30.5	33.6	27.5	29.6	29.1	77.3	33.5	20.2	17.4	43.3	30.2	NS	14.8	22.0	93.8		
CV	28.7	26.9	26.9	22.7	42.1	43.1	36.5	37.8	31.4	27.5	42.3	39.5	38.2	66.1	44.9	53.4		

Table 4. Cumulative yield per tree (Kg) after 10 years of 'Starkspur Supreme Delicious' on 15 rootstocks in the 1984 NC-140 trial.

Site	SDL	P.18	A.313	B.490	MAC.1	M.4	M.7E	P.1	M.26E	C6	MAC.39	B.9	P.2	P.16	P.22	Avg.	LSD .05	C.V.
AR	68.8	98.0	135.7	85.7	92.1	144.7	119.0	98.6	136.7	137.0	95.6	73.7	76.4	58.2	19.6	96	24.4	36.4
BRC	247.7	263.7	286.3	292.8	268.9	275.0	235.2	314.5	244.0	280.4	191.3	151.8	149.8	115.6	90.0	227	51.8	30.6
CA	540.3	780.5	674.0	524.6	449.5	835.2	416.8	378.5	347.3	169.3	226.4	83.5	89.2	32.6	52.6	376	111.1	69.2
CO	167.6	92.5	104.0	87.4	81.8	146.5		114.6	97.0	70.0	87.6	83.3	56.9					
GA	354.7				404.0	395.4	312.2	286.5	232.0		182.6	115.1				285	79.1	36.0
IA	140.3	174.1	186.8	149.2	177.3	238.6	198.8	173.7	216.0	164.0	153.7	130.1	97.1	72.8	32.0	153	27.6	35.2
IL	289.2	380.5	335.7	279.5	383.7	407.7	310.8	265.9	395.1	271.0	270.5	175.3	140.4	85.0	57.8	276	106.9	40.8
IN	302.3	383.9	381.1	314.1	322.5	447.0	324.2	329.5	297.7	204.2	187.0	114.8	98.3	27.0	29.7	250	64.3	52.8
KS	86.6				95.1	172.7	169.3	176.3	153.1		67.0	30.5			31.0	109	36.1	55.0
KY	154.4				194.2	226.0	181.8	179.7	185.7		179.1	118.1			35.0	161	50.5	34.4
MA	268.8	338.1	332.7	290.0	262.8	351.5	274.7	258.0	172.3	207.0	141.7	139.6	114.8	48.2	39.2	215	56.2	47.2
ME	58.5	88.4		96.4	47.7		72.7	112.3	67.1	74.0	31.0	68.1	42.4		11.8			
MEX	90.8				96.8	124.8	160.5	151.3	153.7		71.9	118.0			26.0	110	29.2	39.8
MI	250.8	302.8	240.0	247.7	312.9	345.3	256.5	321.1	270.9	260.0	208.7	193.1	132.1	127.0	61.0	235	53.1	33.6
MN	74.3	98.7	90.0	79.3	80.0	35.6	91.8	88.5	136.8	111.3	68.7	95.2	47.0	53.8	57.6	80	31.0	32.3
MO	185.0				213.8	245.0	195.2	163.6	144.8		90.6	114.3			17.0	152	61.3	45.9
NC	115.0	144.3	139.0	121.6	144.5	138.0	159.4	127.6	144.8	130.6	75.0	81.0	38.8		53.0	115	36.4	32.7
NJ	276.8				270.8	282.9	286.8	301.3	266.4		144.4	77.6			36.0	215	56.5	47.0
NOS	174.6				248.6	218.4	249.3	234.3	176.6		96.7	114.5			17.7	170	37.3	46.7
NY	92.8	138.6	154.2	93.3	105.8	150.2	79.3	99.8	63.8	59.0	52.0	60.8	50.6	20.4	16.0	81	30.4	57.1
OH	370.3	385.0	355.6	302.4	356.1	351.3	369.0	364.3	348.3	339.7	264.8	214.6	155.5	105.2	58.8	289	63.3	36.6
ONT	105.0				149.4	121.1	184.4	196.2	196.8		112.1	149.5			60.8	141	38.0	32.6
OR	216.9	342.7	255.8	274.3	233.6	301.5	150.3	295.5	230.8	177.1	149.6	152.6	90.0	104.1	52.7	201	42.4	42.1
PA	172.3	153.4	165.8	156.3	148.9	149.7	151.1	130.9	111.5	84.5	87.8	78.5	40.5	29.4	22.7	112	37.5	45.9
TN	45.7				48.7	50.1	78.2	55.2	42.8		53.1	48.2			19.0	49	21.1	31.1
UT	214.8	269.9	251.8	223.5	222.4	289.5	201.7	312.4	118.6	152.2	173.8	107.8	64.4	65.8	61.0	181	37.5	46.0
VA	341.1	394.0	414.8	322.3	344.8	447.7	306.7	309.8	351.2	246.5	233.3	176.0	116.3	59.2	49.7	274	62.4	45.4
WA	104.4	142.5	120.8	147.6	117.2	140.3	161.1	134.3	93.4	95.2	66.1	88.0	67.7	52.5	36.8	104	23.6	35.8
WI	202.7	277.9	291.7	276.7	175.9	250.0	197.5	227.5	239.0	189.3	93.3	175.9	103.6	55.8	38.8	186	80.0	43.2
WV	163.3				228.2	228.3	223.5	261.6	230.7		162.0	124.8			59.4	186	41.4	34.6
Avg	201.7	280.9	267.4	232.2	219.5	262.9	215.7	226.3	203.6	182.1	139.2	118.1	92.9	67.8	41.9	183		
LSD	54.7	76.8	66.6	50.6	51.7	55.6	53.8	71.3	57.6	51.0	70.6	34.2	48.3	49.4	26.4	66.8		
C.V.	56.4	56.3	52.5	48.3	31.0	60.3	39.8	31.3	44.2	41.4	33.2	40.9	39.7	45.6	72.6	---		

Table 5. Yield efficiency (yield ÷ TCA, kg/cm²) after 10 years of 'Starkspur Supreme Delicious' on 15 rootstocks in the 1984 NC-140 trial.

Site	SDL	P.18	A.313	B.490	MAC.1	M.4	M.7E	P.1	M.26E	C6	MAC.39	B.9	P.2	P.16	P.22	Avg.	LSD .05	C.V.
AR	.52	.65	.87	.69	.81	1.18	1.14	1.01	1.48	1.55	1.40	2.19	3.63	2.48	1.56	1.42	.72	58.2
BRC	2.18	2.48	3.42	2.51	2.60	2.57	4.03	4.00	3.14	3.84	3.69	4.79	3.99	3.87	3.27	3.36	.59	22.5
Ca	2.55	2.62	2.86	2.65	2.88	3.10	5.12	4.34	4.16	4.47	5.00	4.92	4.78	5.11	4.24	3.92	.55	26.0
CO	.49	.68	.83	.80	.62	1.04	1.79		1.96	1.39	1.50	2.61	1.36	1.46	1.57			
GA	1.51				1.85	1.88	2.37	2.47	2.94		3.19	2.48				2.34	.63	24.2
IA	.82	.97	1.09	1.10	1.18	1.61	2.07	1.64	2.61	2.85	2.67	3.91	3.11	3.77	2.62	2.13	.34	40.8
IL	1.37	1.84	1.74	1.40	1.84	2.23	2.38	3.00	3.62	4.08	4.02	4.52	4.41	4.24	4.92	3.04	.74	41.7
IN	1.78	2.05	2.13	2.04	2.21	3.22	3.29	3.52	4.06	4.01	4.76	4.60	3.54	2.80	2.98	3.13	1.07	30.6
KS	.39				.39	.60	1.18	.90	1.23		.96	1.00			1.02	.85	.22	37.3
KY	1.15				1.47	1.63	1.73	2.45	1.79		2.40	2.55			1.74	1.88	.95	25.6
MA	2.17	2.65	2.80	2.64	2.33	3.98	4.12	4.12	4.47	5.35	3.90	5.54	5.80	5.81	4.40	4.01	.81	31.5
ME	.94		.98	1.07	.63		1.43	2.29	2.15	2.68	2.10	2.98	2.55		2.51			
MEX	1.17				2.81	2.26	2.65	2.17	2.42		1.96	1.83			1.23	2.06	.45	27.9
MI	1.26	1.53	1.26	1.56	2.00	2.01	2.06	2.56	3.33	3.58	4.00	6.17	5.63	6.67	4.68	3.22	1.02	57.1
MN	.71	.83	.77	.71	.63	1.42	1.16	1.00	1.70	1.45	1.28	1.95	1.11	1.06	1.43	1.15	.39	34.1
MO	1.17				1.06	1.21	1.40	2.27	2.43		2.20	1.77			.66	1.57	NS	39.2
NC	.86	1.14	2.64	.74	1.45	1.00	1.36	1.84	2.13	2.34	1.03	2.04	.95		1.09	1.47	NS	41.5
NJ	2.11				2.01	2.40	3.04	3.54	3.69		3.90	3.76			3.64	3.12	.58	24.2
NOS	1.44				1.69	2.17	2.65	2.58	2.73		2.91	3.64			2.37	2.46	.47	26.6
NY	.76	.72	.89	.59	.71	1.33	1.01	1.85	1.29	1.38	1.29	2.25	2.46	1.84	1.81	1.35	.48	43.7
OH	2.21	2.46	2.30	2.07	2.62	2.94	3.51	3.67	4.34	4.05	4.69	4.43	4.61	5.27	3.90	3.53	1.91	26.2
ONT	.73				1.24	1.07	2.26	1.92	2.59		2.16	4.43			4.49	2.32	.96	58.3
OR	1.60	2.05	1.69	1.80	1.77	2.42	1.60	2.50	2.24	2.31	2.29	3.55	3.27	3.76	3.30	2.41	.47	30.2
PA	2.18	1.44	2.24	1.97	1.57	2.11	2.34	2.28	2.37	2.23	2.32	2.53	2.32	2.97	2.60	2.23	NS	16.7
TN	.68				.60	.78	1.10	1.18	1.14		1.25	1.51			1.67	1.10	.83	32.9
UT	1.34	1.51	1.39	1.67	1.39	1.85	2.55	2.61	2.95	2.40	2.31	4.19	3.39	4.28	3.67	2.50	.66	40.5
VA	1.72	2.68	2.02	1.62	1.98	2.43	2.48	3.05	3.08	3.09	3.15	4.02	3.48	3.11	2.62	2.70	.44	24.9
WA	.75	.92	.86	1.07	1.01	1.13	1.62	1.93	3.21	4.61	3.39	2.71	2.89	4.00	3.32	2.22	NS	40.7
WI	1.45	1.69	2.03	1.88	1.75	2.51	2.51	2.87	3.19	2.94	2.51	3.82	3.58	3.25	3.53	2.63	.53	28.7
WV	1.09				1.50	1.56	1.89	2.21	2.23		2.75	2.71			1.91	1.98	.66	28.0
Avg	1.34	1.68	1.83	1.70	1.61	1.95	2.30	2.48	2.73	3.14	2.76	3.34	3.49	4.67	2.76	2.48		
LSD	.38	.80	1.06	1.37	.37	.40	.41	.73	.67	2.18	1.28	.77	1.02	NS	1.29	.91		
C.V.	44.0	42.1	43.1	51.8	49.1	41.6	44.2	42.1	34.3	37.2	46.9	37.9	37.3	85.3	44.1	---		

advantages among the rootstocks producing seedling-sized trees, had better than average yields in 5 sites, average yields in 6 sites, and below average in 7 sites.

Averaged over all rootstocks, the sites with the greatest yield efficiency (yield ÷ TCA) were MA, CA, OH, BRC, and those with lowest efficiency were KS, MN, TN, NY, AR, and NC (Table 5). It is noteworthy that CA had large tree size and still had high yield efficiency, while the other sites with high efficiency had more moderate tree size. Of the six rootstocks that produced seedling-sized trees, yield efficiency of trees on A.313 and B.490 rootstocks were more variable than the others as measured by LSD value. A comparison of LSD values across trees on M.26EMLA and smaller rootstocks indicated that M.26EMLA and B.9 were less variable than the others.

Results presented in this paper should prove helpful to growers considering some of these rootstock options. Identification of a trial site with similar climatic conditions to specific production areas should be helpful in predicting the potential performance of these rootstocks.

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Fruit Varieties Journal 50(1):18-24 1996

Horticultural Characteristics of 'Starkspur Supreme Delicious' Apple on 15 Rootstocks at 24 Sites

NC-140[1]

Abstract

A rootstock trial of 'Starkspur Supreme Delicious' trees on 15 rootstocks was established in 1984 by the NC-140 regional cooperative project. Horticulturists who have worked with and managed this trial subjectively rated various horticultural characteristics of the scion and rootstocks of these trees in 1994. Characteristics related to branching, anchorage, pruning and training, and root suckering were among those rated. The potential of each rootstock for slender spindle or central leader type management was also rated.

[1]Authors listed in Table 1.

Field trials of apple rootstocks with various scions have been done for many years and large amounts of quantitative data have been published regarding the performance of trees in these trials. Quantitative data regarding survivability, growth, and yield of 'Starkspur Supreme Delicious' trees on 15 rootstocks in the NC-140 trial established in 1984 are contained in other sections of this volume (1, 2).