

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

NC-140¹

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.

¹Authors 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).

Horticulturists who have worked with and managed this NC-140 trial at the planting sites have observed a great deal about various important horticultural characteristics of the different scion/rootstock combinations. Many of these characteristics are not described in the quantitative data collected but may be useful in choosing a rootstock for a particular use.

The objective of this effort was to subjectively rate various horticultural characteristics of the scion and rootstocks of trees in the NC-140 rootstock trial established in 1984.

Materials and Methods

The sites and experimental design for this trial were described in a previous paper (1). Cooperators who participated in rating the horticultural characteristics of the trees at their sites are listed in Table 1. Each cooperator rated every tree at their site during the last year of the trial according to

guidelines determined by the NC-140 committee and described below. The ratings for all replications at each of these sites were averaged and the means used as raw data for this paper. Each characteristic was rated on a scale of 1 to 5, with the scale extremes as described in Table 2. Ratings were done for 14 scion characteristics, six rootstock characteristics, and the tree's potential for slender spindle or central leader type management. A rating of 1 or 5 does not necessarily imply a good or bad expression of the characteristic, but only the relative expression between the extremes. Which rating extreme would be more or less advantageous would depend on the management system desired and the requirements of a particular site. Ratings were generally done using a combination of direct observation of the 10-year-old trees and observations accumulated over the previous 10 years. Standard deviations of the overall means were

Table 1. Location and cooperators in the 1984 rootstock trial coordinated by NC-140 who submitted horticultural characteristics ratings for their trees.

Location	Cooperator	Planting Location
(AR) Arkansas	Roy C. Rom, Curt R. Rom	Fayetteville
(BRC) British Columbia	Harvey A. Quamme	Summerland, Canada
(CA) California	Warren C. Micke	Kearney
(GA) Georgia	Stephen C. Myers	Blairsville
(IN) Indiana	Richard Hayden	West Lafayette
(IA) Iowa	Paul Domoto	Ames
(KS) Kansas	Frank Morrison	Manhattan
(KY) Kentucky	Gerald R. Brown	Princeton
(MA) Massachusetts	Wesley R. Autio	Belchertown
(MEX) Mexico	Rafael A. Parra Quezada	Sierra de Chihuahua
(MI) Michigan	Ronald L. Perry	Clarkesville
(MN) Minnesota	Emily E. Hoover	St. Paul
(MO) Missouri	Michele R. Warmund	New Franklin
(NJ) New Jersey	Edward F. Durner	Cream Ridge
(NC) North Carolina	Eric Young	Fletcher
(NOS) Nova Scotia	Charles G. Embree	Kentville, Canada
(OH) Ohio	David C. Ferree	Wooster
(ONT) Ontario	Donald C. Elfving, Ghassem Tehrani	Simcoe, Canada
(OR) Oregon	Porter Lombard, Anita Azarenko	Corvallis
(PA) Pennsylvania	Loren D. Tukey, Robert M. Crassweller	University Park
(TN) Tennessee	Charles C. Mullins	Crossville
(UT) Utah	David R. Walker, J. Lamar Anderson	Farmington
(VA) Virginia	John A. Barden	Blacksburg
(WV) West Virginia	Tara A. Baugher	Kearneysville

Table 2. Description of ratings used to evaluate various horticultural characteristics of 'Starkspur Supreme Delicious' apple on 15 rootstocks grown in up to 26 sites.

Horticultural characteristic	Rating = 1	Rating = 5
Scaffold limb crotch angles	Crotch angles of scaffolds very narrow	Crotch angles of scaffolds at 90 degrees.
Ease of inducing scaffold limbs	Very difficult. Frequent blind wood on central leader	Easy. Most central leader nodes branch.
Lower scaffold limb dominance	Very low dominance. Limbs weak. Little terminal growth on limbs.	Very high dominance. Limbs large compared to trunk.
Central leader dominance	Very low dominance. Central leader weak compared to upper laterals.	Very high dominance. Vigorous central leader.
Crown symmetry	Low symmetry. Branches clustered on one side.	Highly symmetric. Branches evenly distributed.
Trunk leaning from soil line	Very upright. No leaning.	Leans beyond 45 degrees.
Top of tree leaning	Very upright. No leaning.	Leans off to side more than 45 degrees.
Thinning-out pruning needed	Very little thinning-out needed.	Very high amount of thinning-out needed.
Water sprout pruning needed	No water sprouts.	High number of water sprouts each year.
Trunk roundness	Very lopsided trunk.	Round trunk.
Ease of central leader training	Very difficult to train as central leader.	Very easy to train as central leader.
Spuriness of fruiting wood	Very few spurs.	Very highly spurred (spur bound)
Terminal vegetative growth	Terminal growth very little.	Terminal growth very long and vigorous.
Apical growth cessation timing	Apical growth stops relatively very early.	Apical growth stops relatively very late.
Potential as a slender spindle.	Very low potential for slender spindle.	Very high potential for slender spindle.
Potential as free standing central leader	Very low potential for free standing central leader.	Very high potential for free standing central leader.
Burrknots	No burrknots visible.	Burrknots over most of rootstock shank.
Surface roots	No surface roots visible.	Many surface roots visible around trunk.
Suckers from root crown	No suckers originating from root crown.	High number of suckers from crown.
Suckers away from trunk	No suckers originating away from trunk.	High number of suckers away from trunk.
Smoothness of graft union	Graft union very smooth. No difference in rootstock and scion diameters.	Graft union very rough or bark irregular or excessive difference in diameters.
Wobble in planting hole	Soil very tight against trunk at soil line.	Large cone-shaped hole around trunk and/or tree very loose in hole.

calculated as an indication of the variation in ratings across sites.

Results and Discussion

All trees were trained as free-standing, central leader type which may have biased some characteristics' rat-

ings in favor of rootstocks that would generally be well suited to this type of management system. However, comparative ratings across sites can offer insight into how this scion responded on the various rootstocks tested under this type of management system. Over-

Table 3a. Means of ratings of horticultural characteristics of ‘Starkspur Supreme Delicious’ on 15 rootstocks after 10 years in the NC-140 rootstock trial established in 1984. Ratings explained in Table 2.

Number of Trials in Means	SDL 25	P.18 15	ANT.313 14	B.490 16	MAC.1 25	M.4 25	M.7E 25	P.1 25	M.26E 25	C.6 15	MAC.39 25	B.9 24	P.2 15	P.16 14	P.22 23
Scion characteristics															
Scaffold limb crotch angles	3	3	3	3	4	3	4	4	4	4	4	4	3	4	3
Ease of including scaffold limbs	4	4	4	4	4	4	4	4	4	4	4	4	4	4	3
Lower scaffold limb dominance	3	3	4	3	3	3	4	3	4	4	4	3	3	3	3
Central leader dominance	4	4	4	4	4	4	4	4	4	3	4	3	2	3	2
Crown symmetry	4	4	4	4	4	4	4	4	4	4	4	4	3	3	3
Trunk leaning from soil line	3	3	2	3	3	3	3	3	3	3	3	3	3	3	3
Top of tree leaning	3	2	2	2	3	3	3	3	3	3	3	3	3	3	3
Thinning-out pruning needed	3	3	3	3	3	3	3	3	3	3	3	3	2	2	3
Water sprout pruning needed	3	3	3	3	3	3	3	3	3	2	3	3	2	2	3
Trunk roundness	4	5	4	4	4	4	4	4	4	4	4	4	5	5	5
Ease of central leader training	4	4	4	4	4	4	4	4	4	4	4	3	3	3	2
Spuriness of fruiting wood	3	3	3	3	3	3	4	3	4	4	4	4	4	4	5
Terminal vegetative growth	4	3	3	4	4	4	4	3	4	3	4	3	2	3	2
Timing of apical growth cessation	4	4	4	4	4	4	4	4	4	4	4	3	4	4	4
Potential as slender spindle type	2	2	1	2	2	2	2	3	3	4	4	4	4	4	4
Potential as central leader type	4	4	4	4	4	4	4	4	4	3	4	2	2	2	2
Rootstock Characteristics:															
Burrknots	3	2	2	2	2	3	3	3	3	2	3	3	2	2	3
Surface roots	3	2	2	2	3	3	3	3	3	2	3	3	2	2	3
Suckers from root crown	3	2	3	2	3	3	3	3	3	2	3	3	2	2	3
Suckers away from trunk	3	2	2	2	3	3	3	3	3	2	3	3	2	2	3
Smoothness of graft union	3	3	2	3	3	3	3	3	3	3	3	3	3	3	3
Wobble in planting hole	3	2	2	2	3	3	3	3	3	3	3	2	3	2	

Table 3b. Standard deviations of ratings of horticultural characteristics of 'Starkspur Supreme Delicious' on 15 rootstocks after 10 years in the NC-140 rootstock trial established in 1984. Ratings explained in Table 2.

Number of Trials in Means	SDL 25	R18 15	ANT313 14	B.490 16	MAC.1 25	M.4 25	M.7E 25	P1 25	M.26E 25	C.6 15	MAC.39 25	B.9 24	R2 15	R16 14	R22 23	
Scion characteristics																
Scaffold limb crotch angles	1.1	0.4	0.7	0.4	1.0	1.0	1.0	0.9	1.0	0.6	0.9	1.1	0.9	1.2	1.6	
Ease of inducing scaffold limbs	0.7	0.9	0.7	0.6	0.6	0.8	0.6	0.9	0.8	0.8	0.8	1.2	0.8	0.9	1.4	
Lower scaffold limb dominance	1.0	0.8	0.6	0.7	0.9	0.9	0.9	0.8	1.1	0.9	0.9	1.1	1.2	0.9	1.2	
Central leader dominance	1.0	0.8	0.6	0.5	0.8	0.8	0.9	0.7	1.0	1.1	0.8	1.0	1.1	1.1	1.0	
Crown symmetry	0.8	0.5	0.8	0.5	0.9	0.7	0.7	0.8	0.6	0.7	0.6	0.9	1.0	0.9	0.9	
Trunk leaning from soil line	1.9	1.6	1.7	1.7	1.8	1.4	1.4	1.5	1.5	1.2	1.1	1.3	1.2	1.1	1.3	
Top of tree leaning	1.7	1.4	1.5	1.4	1.5	1.4	1.3	1.2	1.1	1.1	1.0	1.0	1.0	0.9	1.1	
Thinning-out pruning needed	1.0	1.0	0.7	0.7	0.9	0.9	0.9	1.0	1.3	1.0	1.3	1.6	1.4	1.5	1.8	
Water sprout pruning needed	1.1	1.3	0.9	1.0	1.0	1.0	1.0	1.2	1.3	1.2	1.4	1.7	1.5	1.6	1.8	
Trunk roundness	0.7	0.5	1.0	0.4	0.7	0.8	0.9	0.9	1.0	0.6	0.9	1.1	0.5	0.4	0.6	
Ease of central leader training	0.7	0.5	0.3	0.2	0.7	0.7	0.8	0.6	0.9	0.9	0.8	1.1	1.0	0.9	1.0	
Spuriness of fruiting wood	1.0	1.0	0.9	0.9	1.0	0.9	0.9	0.8	0.9	0.7	0.8	0.6	0.6	0.9	0.5	
Terminal vegetative growth	1.1	1.2	0.8	0.8	0.8	0.7	0.9	0.7	1.2	1.1	0.8	1.0	0.9	1.0	0.6	
Timing of apical growth cessation	1.2	1.0	1.0	0.8	1.3	1.1	1.3	0.9	1.1	0.5	0.9	1.5	1.0	1.0	1.2	
Potential as slender spindle type	0.9	1.2	0.8	0.8	1.0	1.2	1.2	1.1	1.2	0.8	0.8	1.0	0.9	1.0	1.0	
Potential as central leader type	0.8	1.1	1.1	0.7	0.7	0.9	0.7	0.8	0.9	1.0	1.0	1.2	0.9	1.2	1.0	
Rootstock Characteristics:																
Burrknots	1.7	1.7	1.0	1.6	1.8	1.7	1.6	1.4	1.5	1.5	1.7	1.8	1.5	1.6	1.7	
Surface roots	1.7	1.7	1.5	1.8	1.7	1.8	1.8	1.8	1.7	1.4	1.8	1.7	1.5	0.9	1.7	
Suckers from root crown	1.2	1.5	1.0	1.6	1.3	1.3	1.1	1.2	1.7	1.6	1.5	1.7	1.7	1.2	1.5	
Suckers away from trunk	1.3	1.6	1.2	1.8	1.6	1.4	1.3	1.6	1.7	1.4	1.8	1.7	1.5	1.6	1.7	
Smoothness of graft union	1.7	1.7	1.3	1.7	1.4	1.3	1.2	1.1	1.1	1.2	1.1	1.2	1.0	0.8	0.8	
Wobble in planting hole	1.8	1.7	1.4	1.7	1.8	1.6	1.5	1.7	1.7	1.3	1.4	1.2	1.3	0.9	1.4	

Table 4. Ratings of potential for Slender Spindle or Central Leader Type management of 'Starkspur Supreme Delicious' on 15 rootstocks. Ratings explained in Table 2.

Site	SDL		P.18		ANT.313		B.490		MAC.1		M.4		M.7E		P.1		M.26E		C.6		MAC.39		B.9		P.2		P.16		P.22	
	SS	CL	SS	CL	SS	CL	SS	CL	SS	CL	SS	CL	SS	CL	SS	CL	SS	CL	SS	CL	SS	CL	SS	CL	SS	CL	SS	CL	SS	CL
AR	1	5	2	5			3	4	3	5	1	5	1	4	1	5	4	5	4	3	4	5	5	3	5	2	5	3	5	1
BRC	1	4	1	5	1	4	1	4	1	5	1	4	2	4	2	4	3	4	4	2	3	3	3	2	4	1	4	1	5	1
CA	1	2	1	1	1	1	2	3	3	4	1	1	4	5	3	4	4	5	3	5	3	4	3	1	2	1	2	1	3	1
GA	1	3							1	4	1	2	3	3	2	3	1	3	3	3	4	3	5	2			4	1		
IA	1	4	5	3	1	4	2	4	1	4	1	4	3	5	2	4	4	5	5	3	4	5	5	4	5	2	5	3	4	1
IN	1	5	1	5	1	5	2	5	1	5	1	5	2	4	3	4	4	3			5	2	1	1	5	1			5	1
KS	1	5							2	4	1	4	3	3	3	3	2	3	5	3	3	3	5	1						
KY	2	3							2	3	2	3	2	3	4	4	2	3			4	4	3	3					3	1
MA	1	5	1	5	1	5	1	5	1	5	1	5	1	5	3	3	2	3			5	1	5	1	5	1	2	1	5	1
MEX	4	5							3	4	5	4	5	4	5	5	5	5	3	4	5	4	5	1					4	5
MI	1	4	1	5	1	5	1	5	1	5	1	4	3	5	1	4	4	3			5	3	5	5	4	1	3	5	5	1
MN	2	4	2	4	2	4	2	4	4	3	4	3	3	4	2	4	4	4	4	1	4	3	5	1	4	3	3	3	4	3
MO	1	4							1	5	1	4	1	4	1	4	2	3	4	4	4	2	4	2					5	1
NC	1	4	3	4	1	3	1	4	1	4	1	4	1	4	2	4	3	5	4	3	4	4	5	3	3	2			3	2
NJ		3							3		3		4		3		3				5		5	1					1	
NOS	1	3							2	3	2	3	2	3	3	4	3	2			4	2							3	1
NY	1	4	1	3	1	5	1	3	1	4	1	4	5	4	2	5	5	4			2	4	1		5	2	4	1	3	1
OH	1	5	1	5	1	5	1	5	1	5	1	5	1	5	2	5	2	5	3	3	2	5	4	2	4	3	5	2	5	1
ONT	1	4							1	4	1	4	1	4	1	4	1	4	2	5	4	3	4	4					4	1
OR	2	5	1	4	1	5	1	4	2	5	2	4	2	5	2	5	2	5			3	5	5	2	5	1	5	2	4	2
PA	1	5	1	5	2	5	2	5	2	5	1	5	1	5	5	3	2	5	3	4	4	3	4	3	5	1	3	3	2	1
TN	3	5							3	4	4	5	3	5	4	4	5	4	3	3	4	4	5	2					4	2
UT	3	4	4	4	4	3	4	3	4	3	4	3	4	4	4	4	4	4			3	4	5	4	4	3	4	3	4	3
VA	3	4	3	4	3	4	3	4	3	4	3	4	3	4	3	4	3	4	4	4	3	4	4	4	3	4	3	3	3	3
WV	1	3					2	5	2	5	1	4	3	5	3	1	4	3	3	4	4	4	3	4					3	1

all rating means for the scion characteristics generally were 3's or 4's (Table 3a) with standard deviations ranging from 0.5 to 1.5 (Table 3b). Rootstock characteristics rating means generally were 2's or 3's (Table 3a) with standard deviations ranging from 1.0 to 1.8 (Table 3b), indicating greater variation between sites than with scion ratings. Rating means on the tree's potential for slender spindle or central leader type management generally ranged from 2's to 4's (Table 3a) with standard deviations from 0.8 to 1.2 (Table 3b). For most rootstocks, these two rating means were two points apart, indicating a generally held preference for potential as either slender spindle or central leader type, but not both. However, P.1, M.26EMLA, and C.6 had rating means for these two characteristics that were only one point apart and MAC.39 was rated 4 for both, indicating a fairly high potential as both slender spindle and central leader types.

Many of the characteristics' expressions were quite different between sites due to large variations in climatic and edaphic factors. The highest standard deviations across rootstocks among the scion characteristics were

for "trunk leaning from soil line" and "top of tree leaning" (Table 3b), indicating that the trees' ability to remain upright without support varied with site independent of rootstock. This may be due to soil type, tree vigor, fruit load, or a combination of these.

The ratings on potential as a slender spindle or central leader type tree are a useful summary rating of how each rootstock/scion combination responded at each site. Therefore, these two ratings for each site are shown in Table 4. Overall the ratings tended to be similar across sites, however, for each rootstock there are a few sites whose ratings are at opposite extremes of the scale for either tree type. The fact that this much variation in opinion exists indicates that the rootstock choice for a particular management system will continue to be very site-specific.

Literature Cited

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Call for Wilder Medal Nominations

The Wilder Medal Committee of the American Pomological Society (APS) invites nominations for the 1995 Wilder Silver Medal Award. All active members of APS are eligible to submit nominations. The Wilder Medal was established in 1873 by the American Pomological Society in honor of Marshall P. Wilder, the founder and first President of the Society.

The Wilder Medal is conferred on individuals or organizations which have rendered outstanding service to horticulture in the broad area of pomology. Special consideration is given to work relating to the origination and introduction of meritorious varieties of fruit.

Significant contributions to the science and practice of pomology other than fruit breeding will also be considered. Such contributions may relate to any important area of fruit production such as rootstock development and evaluation, anatomical and morphological studies, or unusually noteworthy publications.

Specific nomination guidelines can be obtained by contacting committee chairperson, Dennis J. Werner, Department of Horticultural Science, Box 7609, North Carolina State University, Raleigh, NC 27695-7609 (phone 919-515-1226). Please submit your nominations by May 1, 1996. Thank you.