An Evaluation Over 16 Years of Delicious Strains and Other Cultivars on Several Rootstocks and Hardy Interstems[1]

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Delicious has become the most widely planted apple cultivar in the world. The latest survey of Ohio plantings indicate that 33% of young non-bearing trees are Delicious. A recent survey (7) of the literature on Delicious indicates that over 100 different strains or mutations of the parent cultivar exist. All the strains offered for sale have some degree of improved fruit color compared to original Delicious. In addition to fruit color changes, a number of strains have spur type growth habit (a high proportion of laterals are spurs rather than long shoots). Spur growth habit has been shown (5) to reduce tree height 13% and tree spread 38% compared to standard Delicious growth habit on M.7.

Although Delicious has proved popular in the marketplace. its low productivity relative to other cultivars has been questioned (1). The present study reports the performance over 16 years of 13 standard habit and 4 spur habit Delicious strains with a number of other cultivars on M.7 rootstock. Selected strains are also compared to the performance of other cultivars on a number of semi-standard rootstocks and hardy interstems.

The study was established in 1964 at the Mahoning County Branch of OARDC near Canfield, Ohio. Four to 12 trees of each strain were propagated on M.7 and in addition, 5 strains were propagated on apple seedling, M.2, M.12, and M.16 rootstock. Selected cultivars were also top-worked to hardy trunk stems of the following on M.7 rootstocks: Hibernal, Kulon Kitaika and Columbia. The top-working was accomplished over a 2-3 year period (1965-1968) with 3-5 scaffold limbs per tree budded to the cultivar. The cultivars were completely randomized within rootstocks and the rootstocks were spaced as follows: M.2 and M.7 at 22.5′ × 25′ and M.12, M.16 and Apple Seedling at 22.5′ × 30′. The orchard received standard cultural practices and the trees were trained to a central leader without the use of limb spreaders.

The average trunk circumference of the 13 standard habit Delicious strains was 25% greater than the average of the 4 spur strains (Table 1). Change in trunk circumference between 1979 to 1980 was also 38% greater for the standard strains, indicating that they were not only larger, but continued to make more vegetative growth. Standard habit Delicious trees after 16 years of growth were 18% taller and 29% wider than trees with a spur habit. Comparison of tree size in 1980 and in previous reports in 1975 (5) indicates that both types of Delicious had increased in canopy size about 30%. The upright characterisitcs of spur type trees require modifications in pruning techniques and the use of limb spreaders to produce a central leader tree (4).

The average accumulated yield of trees of the spur strains was 35% lower than the standard strains (Table 1). However, the spur strains had a 10% greater productive efficiency judged by the yield per unit of trunk cross-section. Calculating yield/acre based on actual tree spread in 1980 (spur

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15′ × 23′, standard 22′ × 30′). The spurs would have out-yielded the standards 20% over the 16 year period of the trial. The higher tree efficiency and smaller tree size permitting more efficient production/unit of land make the spur types the preferred type of Delicious to plant. Trees of Royal Red had lower yields and the lowest yield efficiency of the standard strains. The relatively high yields of Nickell and Starking were associated with larger tree size with only average productive efficiency. The relatively high yields of Myrtle and Jardine were associated with average tree size and a higher productive efficiency. A comparison of the spur strains indicates that Redspur had the lowest accumulated yield and productive efficiency. Accumulated yields of the other 3 spur strains were not greatly different. However, Sturdeespur appeared to have a higher productive efficiency. A previous report (5) on this planting indicated that the spur strains averaged 31% more fruit per tree than standard strains in the 5 year period following planting. The spur trees began flowering earlier and also appeared to set more fruit than standard strains.

In a comparison of other cultivars, Franklin was the most productive and efficient cultivar in this trial. Mutsu was very productive, but had a very large tree size and was less efficient than several other cultivars. Standard Golden Delicious was very efficient but had low yields per tree and for some unexplained reason in this planting, tree size was smaller than expected. Eleven-year-old trees of Golden Delicious (2) in an adjacent planting had a trunk circumference of 38.9 cm or essentially the same as these 16-year-old trees. Holiday had a low yield/tree and low efficiency. This characteristic has been reported in previous studies (3, 6).

Since this was a relatively long term trial with a number of cultivars and rootstocks, the consistency of production over the mature production years (1971-1980) was evaluated by the calculation of the coefficient of variation. The lower the value the more consistent the production. Frost eliminated production in 1970 and reduced yields in several years but did not eliminate the crop of any cultivar during the test period. HiEarly was the most consistent producer of the standard strains and Chelan Red, Red Queen and Rypcyski the most variable (Table 1). There was little difference in the consistency of production of spur and standard strains. Jonathan, Mutsu and Golden Delicious (both standard and spur type) were more consistent producers than Delicious of either growth habit. The consistency of production inherent in some cultivars will likely become more important as growers face more competitive economic conditions.

Dennis (1) in his review on factors affecting yield of Delicious indicated that fruit set may be one of the primary factors causing low yields. In 1978, bloom and set were counted on 5 trees of each of 10 standard and 4 spur strains in this planting (Table 2). The differences in set were not significant among the strains or between standard and spur strains. Flower and fruit density was slightly lower on spur strains compared to standard strains. Although this is only one year's data, fruit set did not appear to explain the difference in yield efficiency between spur and standard Delicious strains.

M.2 caused a 15% reduction in trunk circumference of standard Delicious and a 19% reduction in spur strains (Table 3). M.7 was slightly more dwarfing causing 21% and 29% reductions in standard and spur strains, respectively, compared to apple seedling. Measurement of tree height and spread on M.2 and M.7 verify and expected dwarfing of these two root-

stocks. Trees of most cultivars on M.2 were only slightly larger than on M.7. Trees of M.12 were generally 10-24% larger than on M.16, based on trunk circumference measurements. Comparison of tree height and spread indicated that M.12, M.16 and apple seedling trees were similar in size.

The average accumulated yield per tree of standard habit Delicious was increased by all the clonal rootstocks with M.2 resulting in a 50% larger

Table 1. Growth, yield and yield variation of 13 standard and 4 spur habit Delicious strains and 8 cultivars on M.7 over 17 years, planted in 1964 at the Mahoning County Branch, OARDC.

	No. trees	Trunk circ. cm	Tree Ht. m	Tree spread m	Accum. yield/tree lbs.	Average yield/tree/yr lbs.	Accum yield effic. lbs/cm	Yield co-effic. variation
Standard Habit Delicious								
Chelan Red	5	61.5	5.7	6.6	1637	96	5.4	85
Hi-Early	5	58.7	5.4	6.4	1769	104	6.5	50
Houser	5	57.6	6.5	6.2	1735	105	6.6	61
Imperial	4	56.2	5.7	5.8	1494	88	5.9	80
Jardine	5	56.4	5.0	6.5	1869	97	7.4	75
Myrtle	5	58.5	5.9	6.7	1828	107	6.7	67
Nickell	6	65.0	6.2	7.3	2006	118	6.0	77
Red King	7	61.5	5.5	6.6	1659	98	5.5	61
Red Prince	6	59.0	5.5	6.6	1482	87	5.3	70
Red Queen	4	58.9	5.4	6.8	1610	95	5.8	87
Royal Red	6	52.8	4.9	5.8	1097	53	4.9	61
Rypcyski	4	59.8	5.5	6.8	1764	103	6.2	91
Starking	12	64.3	5.5	6.6	1890	111	5.7	72
Average	5.7	59.2	5.6	6.5	1680	97	6.0	72
Spur Habit Delicious								
Sturdeespur	5	43.3	4.3	4.6	1081	64	7.2	79
Red Spur	6	46.0	4.9	4.7	896	53	5.3	70
Starkrimson	12	45.9	4.9	4.7	1274	75	7.6	63
Wellspur	10	47.9	5.1	5.2	1127	66	6.2	61
Average	8.3	44.3	4.8	4.8	1094	64.5	6.6	68
Cultivars								
Franklin	5	59.4	5.4	6.8	2697	159	9.6	89
Golden Delicious	7	38.3	4.0	3.8	1130	66	9.7	55
Holiday	13	55.9	4.7	5.2	1297	76	5.2	73
Idared	6	60.7	5.0	5.9	2161	127	7.4	67
Jonathan	6	56.4	4.9	5.9	1689	99	6.7	49
Melrose	5	61.6	6.1	6.0	2165	127	7.2	59
Mutsu	6	73.6	5.4	6.5	2587	157	6.0	49
Sundale	5	38.2	3.7	4.0	1104	65	9.5	55
Average	6.6	55.6	4.9	5.5	1854	108.9	7.6	62

yield (Table 4). This is even more striking when it is recognized that M.2 and M.7 had smaller tree size and much greater yield efficiency than apple seedling with Delicious. M.2 was generally more productive with Delicious than M.7 judged by the 2 measurements of yield and yield efficiency. Yield of spur habit Delicious was particularly improved by M.2 with M.7 and M.12 having less effect. In comparing the standard size trees (apple seedling, M.12, M.16), M.16 resulted in a more productive and efficient tree than apple seedling, with both types of Delicious trees.

Melrose on M.2 was a much more consistent producing combination than Melrose on the other rootstocks in the trial (Table 5). Royal Red on M.16 was the least consistent and Hi-Eearly on M.7 the most consistent scion combinations of standard habit Delicious strains compared. The average comparison of cultivar types indicates that yields from trees on M.2 and M.7 were more consistent than on apple seedling, M.12 or M.16.

Tree loss figures for all trees on the various rootstocks were as follows: apple seedling, 12%; M.2, 16% M.7, 16%; M.12, 0%; and M.16, 7%. Most of the loss on M.2 and M.7 was due to heavily cropped trees blowing over. The current practice of budding high and planting slightly deeper than the trees were in the nursery would be expected to alleviate some of the loss

Table 2. Fruit set* and number of fruit per unit of limb cross-sectional area of 10 standard habit and 4 spur habit Delicious strains on M.7 in 1978.

Delicious Strain	% set	Flowers/cm² limb cross-section	Fruit/cm² limb cross-section
Standard Habit Delicious			
Chelan Red	16.7	19.7	1.3
Hi-Early	21.0	14.1	3.7
Houser	20.2	15.9	1.9
Jardine	27.1	12.6	3.0
Myrtle	24.0	17.5	2.6
Nickell	11.5	16.8	.5
Red King	22.6	15.8	2.7
Red Prince	34.2	15.1	1.9
Royal Red	31.4	15.1	2.6
Starking	20.5	14.2	2.6
Average	22.9	15.7	2.3
Spur Habit Delicious			
Sturdeespur	33.3	14.6	2.5
Redspur	19.9	13.8	2.0
Starkrimson	16.7	11.8	1.0
Wellspur	23.1	14.7	1.8
Average	23.2	13.7	1.8

*Data taken on 5 replicate trees of each strain with count limbs averaging 236 flower clusters/tree.

Table 3. Tree size after 16 years of 2 cultivars, 5 standard habit and 3 spur habit Delicious strains on 5 rootstocks planted in 1964 at the Mahoning County Branch, OARDC.

	Trunk Circumference (cm)					Tree Height (m)					Tree Spread (m)				
	A. Sdlg.	M.2	M.7	M.12	M.16	A. Sdlg.	M.2	M.7	M.12	M.16	A. Sdlg.	M.2	M.7	M.12	M.16
Cultivars															
Holiday	78.6	67.3	55.9	80.9	72.5	6.6	5.7	4.7	6.7	6.5	6.8	6.3	5.2	7.3	6.9
Melrose	76.7	69.2	61.6	87.1	86.6	6.1	5.9	6.1	6.6	7.1	7.0	6.7	6.0	7.1	7.7
Average	77.6	68.3	58.8	83.9	79.6	6.4	5.8	5.4	6.6	6.8	6.9	6.5	5.6	7.2	7.3
Standard Habit Delicious															
Chelan Red	73.9	66.1	61.5	90.3	73.2	6.4	6.1	5.7	7.0	6.5	7.4	7.0	6.6	8.0	7.2
Hi-Early	74.4	56.0	58.7	85.6	73.5	6.5	5.4	5.4	6.5	6.7	7.5	6.5	6.4	7.6	7.1
Imperial	70.9	—	56.2	84.0	73.1	6.5	—	5.7	6.9	6.5	6.5	—	5.8	7.3	6.8
Red King	76.8	66.1	61.5	67.6	51.3	6.5	5.6	5.5	5.8	6.6	7.3	6.9	6.6	6.9	7.2
Royal Red	63.8	54.6	47.9	82.4	71.2	6.2	5.0	4.9	6.7	6.3	6.6	6.0	5.8	7.4	7.1
Average	72.0	60.7	57.2	82.2	68.5	6.4	5.5	6.6	6.6	6.5	7.1	6.1	6.2	7.4	7.1
Spur Habit Delicious															
Redspur	66.5	48.5	46.0	72.1	58.4	6.1	4.8	4.8	6.5	6.2	5.2	4.7	4.7	5.7	6.3
Starkrimson	69.7	50.9	45.9	71.7	64.1	6.4	4.9	4.9	6.4	6.3	6.3	5.1	4.7	6.4	6.3
Wellspur	60.8	60.2	47.9	70.7	71.0	6.0	5.7	5.1	6.5	6.5	5.7	5.7	5.2	7.1	6.4
Average	65.7	53.2	46.6	71.5	64.5	6.2	5.1	4.9	6.5	6.3	5.7	5.2	4.9	6.4	6.3

Table 4. Yield performance over 16 years of 2 cultivars, 5 standard habit and 3 spur habit Delicious strains on 5 rootstocks planted in 1964 at the Mahoning County Branch, OARDC.

	Accumulated Yield lbs/tree					Average Yield lbs/tree					Yield Efficiency lbs/cm				
	A. Sdlg.	M.2	M.7	M.12	M.16	A. Sdlg.	M.2	M.7	M.12	M.16	A. Sdlg.	M.2	M.7	M.12	M.16
Cultivars															
Holiday	2984	1921	1297	2790	3552	175	113	76	164	209	6.1	5.3	5.2	5.4	8.5
Melrose	2828	2718	2165	2797	2584	166	160	127	164	152	6.0	7.1	7.2	4.6	4.3
Average	2906	2319	1731	2793	3068	170	136	101	164	180	6.1	6.2	6.2	5.0	6.4
Standard Habit Delicious															
Chelan Red	932	2189	1637	1490	1858	55	128	96	87	109	2.1	6.3	5.4	2.3	4.4
Hi-Early	1158	1922	1769	1966	2442	68	113	104	115	143	2.6	7.7	6.5	3.4	5.7
Imperial	894	—	1494	1425	2190	53	—	88	84	129	2.2	—	5.9	2.5	5.1
Red King	1068	2556	1659	1053	1690	63	150	98	62	99	2.3	7.4	5.5	2.9	8.1
Royal Red	1353	1958	1097	2280	1644	80	115	64	134	97	4.2	8.3	6.0	4.2	4.1
Average	1081	2156	1531	1643	1965	64	126	90	90	115	2.7	7.4	5.9	3.1	5.5
Spur Habit Delicious															
Redspur	823	1335	896	1287	1139	49	78	53	76	67	2.3	7.1	5.3	3.1	4.2
Starkrimson	1116	1710	1274	1218	1560	65	100	74	71	92	2.9	8.3	7.6	3.0	4.8
Wellspur	970	2087	1127	1248	1917	57	122	66	73	112	3.3	7.2	6.2	3.1	4.8
Average	971	1710	1095	1248	1541	57	100	64	73	90	2.8	7.5	6.4	3.1	4.7

experienced. However, care must be taken not to plant too deep on soils with high clay or silt content. Planting too deep in these soils (more than 6 inches deeper than in nursery soil) can result in tree loss in wet years.

Although trunk circumference measurements indicate that trees on the hardy trunk stems were slightly smaller than trees directly on M.7, the overall tree canopy measurements indicate little difference (Table 6). Trees on M.2 had 13% larger trunk circumferences, were 8% taller and had a 12% greater spread than trees on M.7. Yield of all cultivars was higher on M.2 than on M.7 or the hardy trunk stem trees (Table 7). Melrose and Golden Delicious were generally the most productive cultivars on all of the rootstocks. Variability among the hardy trunk stems and cultivars existed with no clear pattern emerging. Golden Delicious on Columbia on M.7 resulted in the smallest tree, and Golden Delicious had the highest yield efficiency of all cultivars. The differences identified between standard habit (Chelan Red) and spur habit (Starkrimson) Delicious were again observed on these rootstocks and hardy interstems. Tree loss of all trees on the various hardy trunk stems were as follows: Hibernal/M.7, 10%; Columbia/M.7, 11.1%; and Kulon Kitaika, 38.9%. A severely cold test winter did not occur during this study and thus, the value of the hardy trunk stock could not be fully evaluated.

The data from this study suggest that the spur habit Delicious strains have a greater yield efficiency than

Table 5. Coefficient of variation for yield of selected cultivars on 5 rootstocks for the 9 main producing years (1971-1980) of the trial at the Mahoning County Branch.

	Co-efficient of Variation for Yield				
	Apple Seedling	M.7	M.2	M.12	M.16
Cultivars					
Holiday	63.1	68.2	59.7	82.9	66.7
Melrose	86.7	43.9	73.1	84.8	75.4
Standard Habit Delicious					
Chelan Red	82.3	74.8	85.2	77.0	81.9
Hi-Early	71.8	59.6	50.2	83.5	76.4
Red King	84.0	79.8	60.7	86.0	60.9
Royal Red	84.9	59.9	60.7	85.0	89.7
Spur Habit Delicious					
Redspur	92.5	58.2	70.3	93.3	82.4
Starkrimson	61.1	74.2	62.9	72.3	82.5
Comparison of Cultivar Types					
Other Cultivars	68.1	54.5	63.3	82.0	66.2
Standard Delicious	75.6	68.3	62.2	80.1	74.9
Spur Delicious	70.5	65.8	64.3	80.5	80.3

Table 6. Tree size after 16 years of 5 cultivars on 2 rootstocks and 3 hardy interstems planted in 1964 at the Mahoning County Branch, OARDC.

	Trunk Circumference (cm)					Tree Height (m)					Tree Spread (m)				
	M.2	M.7	Hib*/ M.7	Col./ M.7	Kul. Kit/ M.7	M.2	M.7	Hib*/ M.7	Col./ M.7	Kul. Kit/ M.7	M.2	M.7	Hib*/ M.7	Col./ M.7	Kul. Kit/ M.7
Chelan Red	66.1	61.5	45.3	54.5	55.5	6.1	6.7	4.6	5.0	5.6	7.0	6.6	5.9	6.1	6.5
Golden Delicious	59.1	38.3	43.0	37.9	37.6	5.1	3.9	5.1	4.1	4.5	5.7	3.8	5.2	4.5	4.7
Idared	—	60.7	48.5	45.6	57.4	—	5.0	5.0	4.7	4.4	—	5.9	5.2	5.3	4.9
Melrose	76.7	69.2	49.5	57.9	66.5	5.9	6.1	4.5	5.8	5.8	6.7	6.0	5.8	6.6	6.6
Starkrimson	50.9	45.9	41.9	45.9	48.5	4.9	4.9	4.9	5.2	5.1	5.1	4.7	6.4	6.3	4.7
Average	63.2	55.1	45.6	48.4	53.1	5.5	5.1	4.8	5.0	5.1	6.1	5.4	5.7	5.8	5.5

*Hib. = Hibernal; Col. = Columbia; Kul. Kit. = Kulon Kitaika. Trees set 22.5′ × 25′
Interstem top-worked 1965-1968.

Table 7. Yield performance over 16 years of 5 apple cultivars on 2 rootstocks and 3 hardy intermediate stocks planted in 1964 at the Mahoning County Branch, OARDC.

	Accumulated Yield lbs/tree					Average Yield lbs/tree					Yield Efficiency lbs/cm				
	M.2	M.7	Hib*/ M.7	Col./ M.7	Kul. Kit/ M.7	M.2	M.7	Hib*/ M.7	Col./ M.7	Kul. Kit/ M.7	M.2	M.7	Hib*/ M.7	Col./ M.7	Kul. Kit/ M.7
Chelan Red	2189	1637	1259	946	1325	128	96	74	55	77	6.3	5.4	7.7	4.0	5.4
Golden Delicious	2587	1130	1579	1168	1422	152	66	75	68	83	9.3	9.7	10.7	10.2	12.6
Idared	—	2161	1716	1386	1213	—	127	100	81	71	—	7.4	9.2	8.4	4.6
Melrose	2718	2165	1733	2205	2428	160	127	101	129	142	5.8	5.7	8.9	8.3	6.9
Starkrimson	1710	1274	1062	950	952	100	74	63	56	56	8.3	7.6	7.6	5.7	5.1
Average	2301	1673	1469	1331	1468	135	98	83	78	86	7.4	7.1	8.8	7.3	6.9

*Hib. = Hibernal; Col. = Columbia; Kul. Kit. = Kulon Kitaika. Trees set 22.5′ × 25′
Interstem top-worked 1965-1968.

standard strains and their compact growth habit and earlier fruiting (5) permits more intensive planting which improves orchard efficiency. On the basis of these factors, spur type Delicious trees would be recommended over standard habit. However, the differences among spur strains are not great enough to suggest one over the other. Although M.7 was not as efficient in fruit production as M.2 in this study, its availability and greater adaptability to various soil types would recommend continued use of M.7 in Ohio. If the efficiency of M.2 in improving the productivity of Delicious can be verified in other studies on other soil types, M.2 stock should be considered for this cultivar as it makes a very desirable sized tree with a spur type scion and early central leader training. The rootstock influence on the various Delicious strains appeared to be consistent enough so that all possible combinations would not have to be evaluated. General performance could likely be predicted from limited testing of a small number of promising strains on new rootstocks.

Literature Cited

1. Dennis, F. G., Jr. 1979. Factors affecting yield in apple with emphasis on 'Delicious.' Hort. Rev. 1:395-422.
2. Ferree, D. C. 1972. Influence of three rootstocks and an interstem on growth and yields of four cultivars. OARDC Res. Sum. 60:13-15.
3. Ferree, D. C. 1977. Performance of 15 apple cultivars on MM 106 and M 26. Fruit Var. J. 32(2):40-42.
4. Ferree, D. C. 1981. Physiological aspects of pruning and training. *IN* Tree Fruit Growth Regulators and Chemical Thinning Short Course Proc. R. B. Tukey and M. W. Williams (eds.) Wash. St. Univ. Coop. Ext., Pullman, WA. pp. 90-104.
5. Ferree, D. C., C. A. Morrison, and L. C. Shew. 1975. Red Delicious apples . . . which strain is best. Ohio Rpt. 60:19-22.
6. Ferree, D. C., D. A. Chandler and J. C. Schmid. 1980. Performance of selected apple cultivars on semi-standard rootstocks in southern Ohio. Fruit Crops 1980. A Sum. of Res. OARDC Res. Circ. 259:1-3.
7. Fisher, D. V. and D. O. Ketchie. 1981. Survey of literature on red strains of 'Delicious.' Wash. St. Univ. Col. of Agr. Bul. 0898, p. 1-17.

Rooting Apple Cultivars for the "Meadow Orchard"

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The "meadow orchard" conceived by English workers requires about 75,000 trees/ha. Economic success of such a system is dependent on very low-priced trees (2). Producing own-rooted trees of cultivars with high rooting potentials could be the most practical means of achieving this requirement. There is also substantial interest in own-rooted trees for more conventional planting systems.

Seventeen cultivars were examined for rooting capacity as modified trench layers (1). One-year whips on MM 106 rootstocks were topped 50 cm above the bud unions and set in trenches at 45° inclination. Two to 6 shoots grew from each whip; soil was ridged up around these shoots in June and July; and the planting was dug the following May. Shoots were graded as well-rooted, poorly rooted, or non-rooted (Table 1). Spigold, a vigorous triploid (2), was outstanding both for rooting success and for degree of root development.

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