Performance of Four Apple Cultivars on Malling 26 Rootstocks Grown in Intensive Culture with Summer Shearing[1]

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Experience with standard (non-spur type) cultivars on dwarfing rootstocks in high density is still limited in North America. When summer shearing to help contain plant size is to be used, projection of likely performance becomes even more elusive. After waiting for some years for acquisition of land for a new research farm, and with no settlement in sight, we initiated an exploratory study in 1973 to gain experience with several cultivars on M 26 stocks, planted in medium to high density, sprayed with growth retardants, and sheared in summer.

This study was conducted in a commercial orchard[3] situated on Braddock gravelly loam at Thurmont, Maryland. Standard (non-spur) Golden Delicious, and non-spur red strains of Stayman, Cortland, and Delicious on M 26 rootstocks were planted as 1-year nursery trees in April, 1973. The Golden Delicious trees were high budded and deeply planted; all others were budded low on the stock, and had to be shallowly planted. This planting consisted of three rows, each of which incorporated varying in-row spacing and a specific training system as indicated in Table I. We had planned between-row spacing of like training systems of 3.6 m for the most dense, 4.2 m for the intermediate, and 4.8 m for the central leader system at the widest spacing. However, due to space limitations and management considerations in a commercial orchard, each training system had to be confined to a single row without replication. Thus yield data reported here are calculated on a hectare basis using the in-row spacing employed, and the between-row spacing planned, but which now is an assumed figure.

Training of intensive systems to be sheared (Rows I and II) was kept as simple as possible. To achieve the narrow configuration of a trapezoid, all laterals in Row I were tied down at the beginning of the second leaf to near-horizontal with an in-row orientation. Ties were made to clips inserted into the soil, or laterals from adjacent trees were bent down and

Table 1. Specifics of high density planting on M 26 rootstocks[z]

	Row I[y] Trapezoid hedge			Row II[x] Pyramid hedge			Row III[w] Central leader		
Spacing in row (m)	0.6	0.9	1.2	0.9	1.5	2.1	1.8	2.7	3.6
No. trees/spacing/cultivar	15	10	7	10	6	4	5	3	3
Trees per hectare[5]	4,485	2,990	2,241	2,562	1,538	1,098	1,121	747	561
Trees per acre	1,815	1,210	908	1,037	622	445	454	303	227
Growth retardant sprays		Yes			Yes			No	
Summer shearing		Yes			Yes			No	

[z]All trees were kept at a maximum height of 2.4 m (8 ft.)
[y]Bottom width held to 1.2 m
[x]Bottom width held to 2.1 m
[w]Spread and head (Heinicke system)
[v]Based on between-row spacings of 3.6, 4.2 and 4.8 m respectively, for Rows I, II and III

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tied to each other. The central leader was headed severely at this time; to encourage early fruiting this was the *only* pruning cut made on these trees. For the pyramid shape in Row II, all laterals were tied down with clips as in Row I, but this was done without regard to compass direction. On these trees too, *only* the central leader was headed. Hand pruning in summer was practiced on both systems the first three seasons to control vigorous upright shoots originating on the near-horizontal scaffold limbs. Subsequent training of these two rows (I and II) involved like treatment of the second and third tier lateral shoots, after which time the trees were large enough to shear by machine in summer. Annual shearing was commenced on Rows I and II in 1976, the fourth leaf, while no shearing was done on the central leader trees in Row III. Corrective pruning was done in the dormant period to shape, to contain, and/or to remove vigorous shoots. When shearing configuration was established, winter pruning by hand involved only thinning-out cuts to keep canopies open for admission of light. The non-sheared trees in Row III were handled in accord with the system developed by Heinicke (2).

Dilute daminozide at 1,000 ppm was sprayed on all trees in Rows I and II in May, 1974, the second leaf. In 1975, the same treatment was applied at the rate of 2,000 ppm. In 1976, 1977, and 1979 a May application of 2,000 ppm was followed by a dilute June application of daminozide at 500 ppm plus ethephon at 250 ppm. No chemical thinning sprays were used in this work. Because of heavy fruit set on Golden Delicious and Stayman trees, considerable hand thinning was practiced to improve fruit size in Rows I and II, and in Row III to keep the central leader dominant.

Machine shearing was done annually, beginning in 1976, in either late July or early August. This treatment was followed each year by re-growth, none of which ever exhibited any winter injury in the years which followed. Nutrition was adjusted to keep leaf N above 2 percent as indicated by leaf analyses of samples taken before shearing. Soil management consisted of weed control with herbicides in the rows, and with a frequently-mowed permanent sod between rows.

RESULTS AND DISCUSSION

For brevity, yields and fruit weights for all cultivars are condensed as means for six crop years, 1975 through 1980 inclusive (Table 2). Golden Delicious, Stayman, and Cortland in the trapezoid hedgerow (Row I) outyielded both of the other systems at wider spacings, but Delicious trees curiously did not. Neither spacing nor tree configuration seemed to have any influence on mean yields of Delicious. Golden Delicious and Stayman were superior cultivars in the training systems used, while Delicious was marginal in yield. Cortland, on the other hand, does not appear to be suited to intensive systems at all; yields of this cultivar were disappointing throughout.

Fruit size for Golden Delicious was consistently smaller than that of other cultivars (Table 2). Both heavy cropping and rather liberal use of daminozide early in the season undoubtedly were contributing factors in this response. Trees which received no daminozide (Row III) produced larger fruits in all cultivars than those which were sprayed; in the latter, Delicious fruits were about 14 percent smaller even though average yield was approximately the same in all three systems.

Annual yields of the two leading U. S. apple cultivars are presented in Table 3 to provide some detail on annual fruiting. American apple growers long have aimed for the magical goal of 47 mt/ha (1,000 bu/acre) on a sustained basis. In this study Golden De-

licious achieved this production in the fourth leaf at all spacings in the trapezoid hedge, and at the closest spacing in the pyramid hedge. Yields on these trees tended to increase slowly each season for the remainder of the study, except in 1979 when production declined drastically—perhaps due to the failure to apply growth retardant sprays the year before to stimulate flower bud initiation. Golden Delicious trees trained to a central leader at wider spacing (Row III) did not achieve the 47 mt/ha figure until 1980, the 8th leaf. Yield was not necessarily correlated with the number of trees per hectare. For example, within the same pruning system in Row I, Golden Delicious trees yielded somewhat greater from 2,241 trees/ha than from 4,485 trees/ha.

Delicious trees flowered as early as those of the other cultivars in response to training techniques and growth retardant sprays, but failed to set in the early years. It is not likely that daminozide sprays influenced fruit set since trees in Row III (no sprays, lower tree density) yielded as well as those in Rows I and II for the six seasons. Not until 1980, the eighth leaf, did Delicious trees yield well, and then the goal of 47 mt/ha was exceeded at all spacings save one in the sheared rows, while the non-sheared, wider-spaced trees in Row II greatly exceeded this goal (Table 3). It is likely that the Delicious trees at the wide spacings of Row III would continue to yield well as tree size was large at the end of 8 years compared to the Golden Delicious trees in the same row, which were markedly contained by early and sustained fruiting.

Fruits were easy to pick from the narrow trapezoid hedge, whereas with the wider pyramid hedge, fruits in the center of the trees were hard to reach due to the length of lower scaffold limbs. For this reason the narrow row is much preferred. Further, the average yield was somewhat higher for Golden Delicious in the narrow hedge; for the entire row yield averaged 50.3 mt/ha for six seasons, whereas in the wider pyramid hedge the mean was 42.1 mt/ha (Table 2). A similar comparison can be found in the data for the Delicious trees.

The central leader tree provided superior light penetration through the tree canopy, and this likely was responsible for earlier and better fruit color development on these trees compared to the sheared trees. At harvest normally the crop was picked from the central leader trees first, and from the trapezoid row last. When color pick-

Table 2. Yield and fruit weight of four cultivars on M 26 stocks planted in high density

Cultivar	Row I Trapezoid hedge Spacings (m) .6	.9	1.2	Mean I	Row II Pyramid hedge Spacings (m) .9	1.5	2.1	Mean II	Row III Central leader Spacings (m) 1.8	2.7	3.5	Mean III
					Yield (mt/ha/year)*							
Golden Delicious	47.8	52.1	51.0	50.3	50.0	47.2	29.1	42.1	25.6	19.8	22.0	22.5
Stayman	42.3	50.2	44.3	45.6	34.2	33.8	35.4	34.5	36.7	33.6	10.5	26.9
Delicious	27.0	19.4	30.3	25.5	21.4	18.3	27.8	22.5	28.2	25.4	22.3	25.3
Cortland	17.9	23.6	22.9	21.5	15.3	19.9	15.2	16.8	20.9	14.4	9.3	14.9
					Fruit weight (gr/fruit/year)							
Golden Delicious	142	164	164	157	150	166	162	159	157	174	160	164
Stayman	166	172	182	173	160	172	156	163	200	207	157	188
Delicious	169	188	184	180	161	185	202	183	186	221	224	210
Cortland	155	169	171	165	167	175	174	172	188	188	168	181

*Mean production/year for 6 crops at assumed between-row spacings of 3.6, 4.2, and 4.8 respectively for Rows I, II, and III.

Table 3. Annual yield of two apple cultivars on M 26 rootstocks in high density in three training systems, planted in 1973.

Row number and Training System	Trees per ha[z]	Yield (metric tons per hectare)													
		Golden Delicious							Delicious						
		1975	1976	1977	1978	1979	1980	Ave.	1975	1976	1977	1978	1979	1980	Ave.
ROW I[y]															
(trapezoid hedge)	4485	11.8	52.5	56.7	71.0	21.6	73.1	47.8	2.2	10.6	19.9	46.2	23.8	59.5	27.0
	2290	7.9	55.6	56.7	83.4	23.1	85.8	52.1	0.8	5.0	21.2	27.2	15.5	46.7	19.4
	2241	9.4	47.4	49.9	75.1	42.6	81.6	51.0	1.3	9.1	25.4	38.6	40.5	66.7	30.3
ROW II[x]															
(pyramid hedge)	2562	7.0	49.0	60.9	82.2	26.2	74.6	50.0	0.8	10.6	19.3	34.6	13.1	50.2	21.4
	1538	2.8	38.1	61.7	67.9	39.3	73.6	47.2	1.2	2.8	14.5	38.9	13.0	49.6	18.3
	1098	4.2	25.1	27.6	45.1	25.0	47.8	29.1	0.6	4.6	16.4	37.7	36.1	71.2	27.8
ROW III[w]															
(central leader)	1121	2.4	23.2	22.8	41.3	16.3	47.5	25.6	1.5	8.9	15.9	38.7	31.2	72.8	28.2
	747	1.0	13.3	22.4	30.7	8.7	43.1	19.9	0.2	2.6	9.8	28.2	43.0	68.3	25.4
	561	0.4	10.6	22.4	32.0	20.8	45.5	22.0	0	3.9	5.9	22.6	33.6	67.5	22.3

[z]Based on assumed between-row spacings of 3.6, 4.2 and 4.8 m respectively, for Rows I, II and III
[y]Bottom tree width limited to 1.2 m
[x]Bottom tree width limited to 2.1 m
[w]Spread and head (Heinicke system)

ing was done, as was the case in most recent years, a higher percentage of the crop was harvested earlier at the wider spacings in the less intensive systems. Fruit color ultimately was satisfactory in the trapezoid hedge, but harvest had to be delayed to acquire adequate fruit color in these trees.

The trees in this study were not supported. Less than a dozen trees ultimately were staked; most were free standing for the 8 years of this work. M 26 rootstocks do not produce as upright a tree as one would like, however, and this planting was no exception. Many trees leaned one direction or another, more of the Stayman cultivar than any other, and this with substantial overgrowth of the scion as reported elsewhere (1). However, comparisons are difficult since the Golden Delicious trees were deep-planted as indicated earlier, and the others were not. It is of interest to note, however, that impressive yields were sustained in all systems with essentially free-standing trees on M 26 rootstocks.

Not all apple cultivars are suited to high density systems, and obviously not all to summer shearing. The terminal fruiting characteristics of Cortland trees likely were responsible for the failure of this cultivar to fruit more heavily, but even at wider spacings with no shearing, Cortland trees did not yield well on M 26. Delicious trees can be induced to flower in intensive systems, but not necessarily to set fruit. It has been shown to be low in production efficiency on M 26, and it was as tardy in fruiting here as it has been on this stock in other work (1, 3).

Fruiting in this study was related strikingly to tree vigor. Delicious and Cortland trees in this planting grew vigorously, always required heavy shearing, developed large trunk diameters in each system, and yielded lightly. Stayman and Golden Delicious trees grew much less, were easy to shear and to hand prune in winter, and fruited very heavily. It seems that one of the requirements for intensive cultivation is the ability to set fruit early and heavily Interestingly enough, of the two cultivars which did so well in this work, one is a partially self-fruitful diploid, while the other is a self-unfruitful triploid.

M 26 is a satisfactory stock for intensive systems, but not for all cultivars in such systems. Stayman exhibited an overgrowth on this stock which appears to be characteristic of this combination (1), and this cultivar also exhibited more leaning than the others. Yet Stayman has been precocious and very heavy yielding on M 26, and during the 8 years of this trial did not indicate that the graft unions were any weaker than those of other combinations. Clearly, Tukey (4) was right in his admonition to consider scions as an entity, and not the separate compoents of stock and scion.

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DESPERATELY NEEDED

Some pieces of mail containing FRUIT VARIETIES JOURNAL, Vol. 34, No. 2 (April 1980) have been lost by the U. S. Postal Service. Most were destined for overseas, particularly to libraries and subscribers in Netherlands, Italy, Hungary, Israel, etc. If any reader would be willing to relinquish a copy of this issue we would be willing to pay $2.00 for it, plus postage to University Park, Pa. Please send the issue to: Dr. L. D. Tukey, Business Manager, 103 Tyson Bldg., University Park, Pa. 16802.