Influence of Interstem Lengths of M.8 Clone *Malus sylvestris Mill.* on Growth, Precocity, Yield, and Spacing of 2 Apple Cultivars[1]

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Abstract. Orchard performance over a 12-year period of 'Delicious' and 'Jonathan' dwarfed with M.8 interstems of different lengths (10, 20 and 30 cm) on Alnarp-2 clonal rootstocks influenced vigor, yield, and annual shoot growth. 'Delicious' required longer interstem material for adequate tree size reduction than did 'Jonathan'. The total yields, based on one tree spacing treatment, were higher the first 6 years from interstem trees than from standard trees, followed by higher yields of standard trees in subsequent years. Projected closer tree spacings according to tree vigor as produced by different interstem lengths suggested that yields per hectar of 'Delicious' could be quadrupled and 'Jonathan' tripled when compared to standard trees.

The use of intermediate stem sections to dwarf and induce hardiness in apple trees has been practiced for many years. Dwarfing by an interstem has a distinct advantage in that a vigorous seedling or clone rootstock can be used resulting in a more strongly anchored tree adaptable to various soil conditions.

In 1943, it was reported that 4-component trees consisting of seedling rootstocks, hardy-stocks, a dwarfing stem section and the scion cultivar were suitable in Iowa (6). Such trees were called "Clark Dwarf". The behavior of apple trees with different clones as intermediate stem sections was reported in 1965 (3). The interstock influenced ultimate tree size. Fruit yield varied with the interstem used, and differed with each scion cultivar. Other research workers have reported on influence on apple of rootstock vigor, quantity and reactions of interstems (1, 7, 8, 9).

We report the long term influence on growth and production of 2 cultivars on a uniform clonal root system with 3 different lengths of the same dwarfing interstem. Only 1 tree spacing was used, so projected tree spacing and performance according to tree vigor and uniform interstem length were estimated.

Materials and Methods

Three-year old apple trees were planted in clay loam soil in 1965 spaced 3.3 × 7.5 m (or 435 trees/hectar). To have uniform root system effects on all trees, the Alnarp-2 clone was used. This hardy rootstock, developed in Sweden, is similar in dwarfing to M.2. The interstem material was M.8, and this was used as 10, 20, and 30 cm stems (Fig. 1). It is more dwarfing than M.9. 'Clark Dwarf' and M.8 has been reported to be identical (2). The cultivars were 'Delicious' ('Red Prince' strain) and Anderson strain of 'Jonathan'. Early bearing associated with some graft combinations required tree training to support heavy cropping trees. Minimum pruning was performed to avoid imposing either an additional dwarfing or invigorating growth factor. The standard trees, however, required more pruning to keep them in similar space, and to prevent them from shading adjacent interstem trees. Each treatment (cultivar-interstem-root system) comprised 10 trees, and was randomized 5 times, with 2 trees per replicate for each cultivar. The data were analyzed by split design. Control trees were on seedling root systems. The trees were planted with the lowest graft union 5 cm above the soil surface. Tree size, yield, and stem diameters of the rootstock, interstem, and scion were recorded annually.

Results and Discussion

Effect on tree size. Tree size of 'Delicious' and 'Jonathan' was influenced by the M.8 interstem. The longer the interstem, the smaller the tree (Table 1 and Fig. 2). 'Delicious', a vigorous cultivar, showed proportional dwarfing according to stem length increase; the less vigorous 'Jonathan' showed less proportional dwarfing. This may have been related to the difference in precocity and vigor of the 2 cultivars. Trees of both cultivars with 30 cm interstem were about half the size of trees on seedling rootstock in height and spread.

Tree size, as influenced by any dwarfing system, is dependent on scion cultivar and tree management. 'Jonathan', being precocious, requires defruiting the leader and early training to develop upright growth. 'Delicious' is less precocious and more upright in growth habit, and therefore, its scaffold branches do not spread as readily (4, 5). These factors influenced the growth patterns of the 2 cultivars when dwarfed with different lengths of M.8 interstem. The length of interstem material had a direct linear effect on vigor of 'Delicious'. Very little "sucker" growth occurred on Alnarp-2.

Interstem influence on shoot growth. A dwarfing interstem superimposed between a more vigorous rootstock and scion alters tree precocity, height, spread, and the amount of annual shoot growth (3). The length of interstem showed a direct influence on shoot growth so that the longer the interstem the less the annual growth (Fig. 3). This

Fig. 1. Intermediate stem sections (10-, 20-, and 30-cm) of M.8 as they appeared the 12th year in the orchard. Top cultivar 'Delicious': A) Standard with no interstem: B) 10 cm; C) 20 cm; and D) 30 cm of M.8 interstems. Bottom 'Jonathan': E) Standard; F) 10 cm; G) 20 cm; and H) 30 cm. Note M.8 tended to slough off outer bark as shown in D with checkering, and H after old cork periderm (bark) had sloughed off leaving clean bark. Also note "dog-leg" (C) which often occur with interstem trees.

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Table 1. Tree trunk diam of Alnarp-2 rootstock, M.8 interstem, 'Delicious' and 'Jonathan' scions respectively dwarfed with 10-, 20- and 30-cm interstem of M.8 and compared to trees on seedling rootstocks.

Interstem Length (cm)	1963		1965		1967		1969		1971		1973	
	Del.	Jon.	Del.	Jon.	Del.	Jon.	Del.	Jon.	Del.	Jon.	Del.	Jon.
					Rootstock trunk diameter (cm)[z]							
30	1.88a	1.86a	2.96a	3.02a	4.66a	4.60a	6.86a	6.24a	8.98a	8.04a	10.54a	9.58a
20	2.00b	2.00b	3.06a	3.16a	4.82a	4.92b	7.34b	6.60a	10.10b	8.66a	12.28b	10.58b
10	2.08c	2.00b	3.32b	3.42b	5.46b	5.24c	8.34c	7.40b	12.02c	10.02c	14.32c	12.00c
Standard	2.18d	2.38c	3.64c	3.92c	6.70c	6.70d	10.66d	10.48d	14.64d	13.50d	18.56d	18.08d
					Interstem trunk diameter (cm)[z]							
30	1.68a	1.72a	2.74a	2.78a	4.48a	4.62a	6.90a	6.06a	8.68a	7.94a	10.50a	9.80a
20	1.80b	1.86b	3.22b	3.28b	5.06b	5.14b	7.98b	7.06b	10.20b	9.06b	12.84b	11.28b
10	2.10c	2.02c	3.58c	3.66c	6.20c	5.82c	9.60c	7.94c	12.60c	10.52c	15.28c	13.10c
					Scion trunk diameter[z]							
30	1.38a	1.20a	2.06a	1.88a	3.16a	3.22a	4.92a	4.46a	6.16a	5.76a	7.50a	7.66a
20	1.38a	1.20a	2.10ab	1.98ab	3.42a	3.38a	5.50b	4.86b	7.44b	6.60b	9.06b	8.40b
10	1.44a	1.18a	2.28b	2.06b	3.96b	3.62b	6.64c	5.48c	8.98c	7.20c	11.06c	9.76c
Standard	1.80c	1.72c	2.98c	2.96c	5.38c	5.18c	8.92d	8.30d	12.34d	11.44d	15.30d	14.30d

[z] Means followed by different letter within a year of each cultivar are significantly different at 1% level.

Fig. 2. Tree height and spread in the 12th year of 'Delicious' and 'Jonathan' dwarfed with 10-, 20-, and 30-cm M.8 interstems and compared to trees on seedling rootstocks (S).

Fig. 3. Annual shoot growth (cm) in the 12th year of 'Delicious' and 'Jonathan' dwarfed with 10-, 20-, and 30-cm interstems and compared to standard(S) trees.

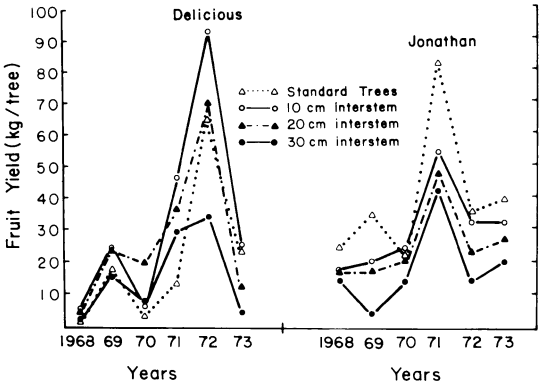

Fig. 4. Average annual yield per tree of 'Delicious' and 'Jonathan' dwarfed with different lengths of interstems, and compared to standard trees.

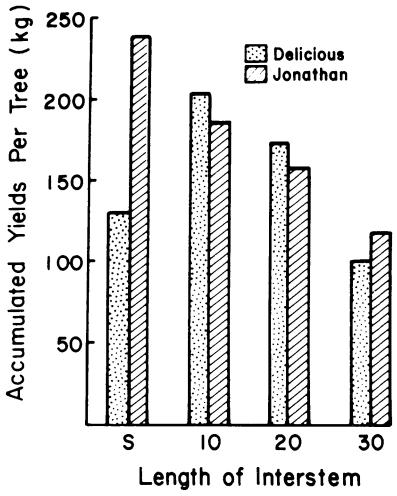

Fig. 5. Accumulated yields per tree for 6 years from 1968 to 1973.

is important in apple tree management, because once the tree reaches desired size less pruning is required.

Annual trunk increments. Annual measurements of trunk diameters of cultivar, interstem, and rootstock revealed a linear relationship of stem diameter to tree size for the first 12 years. Irrespective of interstem length, the interstem had the greatest diameter, followed by the rootstock and the scion. The differences between single-grafted trees and those of the interstem combinations increased annually, and this was greater with 'Jonathan' than with 'Delicious' (Table 1). 'Jonathan' with 10 cm interstem showed the greatest differences when

Table 2. Projected tree numbers per hectar based on current tree spacing trends and adjusted to suit degree of dwarfing of the different lengths of interstems for two cultivars of different vigor.

Cultivars	Interstem length (cm)	Spacing (m)	Tree No. per hectar
Jonathan	Standard	6.6 × 9.0	180
	10	3.6 × 6.6	452
	20	3.0 × 4.8	680
	30	2.4 × 4.2	970
Delicious	Standard	7.8 × 9.0	130
	10	4.2 × 6.6	387
	20	3.6 × 4.8	565
	30	3.0 × 4.2	777

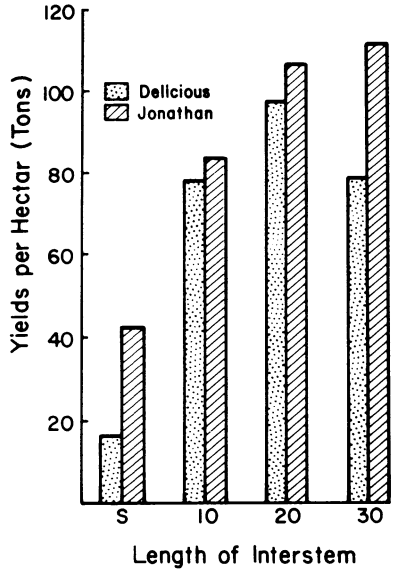

Fig. 6. Projected accumulated total yields per hectare for 6 years dwarfed with different lengths of interstems and standard (S) trees. Tree spacing and tree numbers per hectar were derived from Table 2 and yields extrapolated from actual data. Key: S = 130 trees/hectar for Delicious and 180 for Jonathan; 10 = 387 trees/hectar for Delicious and 452 for Jonathan; 20 = 565 trees/hectar for Delicious and 680 for Jonathan; 30 = 777 trees/hectar for Delicious and 970 for Jonathan.

compared with control trees in diameters of rootstock, interstem, and scion. The 30-cm interstem affected tree size of 'Delicious' more than that of 'Jonathan'. In each case, the interstem significantly overgrew the scion cultivar in trunk diameter. Some seedling rootstocks exhibited overgrowth (Fig. 1E).

Influence on fruiting. Fruit yield can be influenced by many factors including cold injury (blossom frost), cultivar, amount of pruning, rootstock, and/or the length of interstem. Fruit yield in 1967 consisted of only a few apples per tree of 'Jonathan' dwarfed with various lengths of M.8 interstems. None of the trees on seedling rootstocks fruited (Fig. 4). 'Jonathan' was more productive in the early years than 'Delicious'. Accumulated yield for 6 years, at the 3.3 × 7.5-m spacing, showed a decrease in yield with increasing interstem length. 'Delicious' being nonprecocious benefited most from the interstem (Fig. 5). The 1973 yield was reduced by frost during bloom.

Although standard trees (especially 'Jonathan') at the 3.3 × 7.5-m spacing outyielded interstem trees, increased tree numbers per hectar could give a greater yield from the smaller trees. Therefore, best tree spacing was calculated according to cultivar vigor and tree size when dwarfed by interstems to estimate production in proportion to tree density (Table 2 and Fig. 6).

Based on actual performance of trees spaced 3.3 × 7.5-m and projected to tree density according to tree size, the yields per hectar increased with degree of dwarfing. Trees on 'Delicious'/M.8 (20 cm)/A-2 appeared to be ideal for dwarfing and production when compared with trees on seedling and adjusted tree spacing. 'Jonathan'/M.8 (30 cm)/A-2 in projected higher tree density showed increased production when compared to current tree spacing. Extrapolated yields over a 6-year period could be increased from about 20 tons per hectar of standard 'Delicious' to a much as 100 tons using a 20-cm interstem of M.8 and higher tree density. 'Jonathan' with 30 cm interstem showed a similar trend (Fig. 6). Many other factors such as soil types and fertility, root crowding, type of pruning, etc. play a role in tree spacing and subsequent yield.

Literature Cited

1. Beakbane, Beryl A. and W. S. Rogers. 1965. The relative importance of stem and root in determining rootstock influence in apples. *J. Hort. Sci.* 31:99–110.
2. Brase, K. D. 1953. Similarity of the Clark Dwarf and East Malling VIII rootstocks. *Proc. Amer. Soc. Hort. Sci.* 61:95–98.
3. Carlson, R. F. 1965. The effects and relationships of intermediate stem sections on the growth and behavior of apple cultivars. *Proc. Amer. Soc. Hort. Sci.* 87:21–28.
4. Larsen, R. P. 1970. Jonathan. North American Apples: Varieties, Rootstocks, Outlook. MSU Press, Chapter 6:86–98.
5. Maas, Virginia. 1970. Delicious. North American Apples: Varieties, Rootstocks, Outlook. MSU Press, Chapter 4:45–68.
6. Maney, T. J. 1943. Dwarfing apple trees by the use of an intermediate dwarf stem section. *Proc. Iowa State Hort. Soc. Trans.* 78:129–134.
7. Mudler, H. and B. Borck. 1953. On the problem of improving anchorage in small apple trees by the use of vigorous rootstocks with dwarfing rootstocks as intermediates. In German, English summary, Arch. Gartenb. 1:421–427 (Hort. Abstr. 24:2248)
8. Roberts, A. M. and L. T. Blaney. 1967. Qualitative, quantitative, and positional aspects of interstock influence on growth and flowering of the apple. *Proc. Amer. Soc. Hort. Sci.* 91:39–50.
9. White, D. B. 1962. Stock, scion, and interstem reactions in apple trees. Ph.D. Thesis. Iowa State Univ., Diss. Abstr. 22:2142.