Affuence of Interstem Lengths of M.8 Clone Malus sylvestrus training Growth, Precocity, Yield, and Spacing of 2 Apple Cultivars¹ Robert F. Carlson² and Sung D. Oh³ Michigan State University, East Lansing² "*hard performance over a 12-year period of Delicious' and Voanthan' dwarfed with M.8 interstems "*(10. 20 and 30 cm) on Anary-2 clonal rootsocks influence driver, yield, and annual show "*' yields of standard trees in subsequent years. Projected closer tree spaces " different interstem lengths suggested that yields per hectar of Delicious" " when compared to standard trees. In Subsequent years. Projected closer tree spaces than from "*' yields of standard trees in subsequent years. Projected closer tree spaces " different interstem lengths suggested that yields per hectar of Delicious" " when compared to standard trees. In Subsequent years. Projected closer tree spaces the best " united longer interstem lengths suggested that yields per hectar of Delicious" " " the cultivars with 30 cm interstem were about half " " ge to stock to height and spread. " " dwarfing system, is dependent on " " ge us dual for height and spread. " " dwarfing system, is dependent on " " using to develop upright " and as readity (4, 4, 9)" " " at in generation" " " and as readity (4, 4, 9)" " " " " " " "

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

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	1963		1965		1967		1969		1971		1973	
Length (cm)	Del.	Jon.	Del.	Jon.	Del.	Jon.	Del.	Jon.	Del.	Jon.	Del.	Jon.
					Rootstock	trunk diam	eter (cm) ²					
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 diame	rter (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 diam	eter ^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

² Means followed by different letter within a year of each cultivar are significantly different at 1% level.













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

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.

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

Annual trunk increments. Annual measurements of trunk diame-

ters 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 imes 6.6	452
	20	3.0 imes 4.8	680
	30	2.4 imes 4.2	970
Delicious	Standard	7.8 imes 9.0	130
	10	4.2×6.6	387
	20	3.6 imes 4.8	565
	30	3.0 imes 4.2	777



Length of Interstem

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 = 565trees/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 \times 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 \times 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 $\frac{1}{0}$ compared with trees on seedling and adjusted tree spacing. 'Jona-G than'/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 9 20 tons per hectar of standard 'Delicious' to a much as 100 tons using $\frac{0}{2}$ 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.

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