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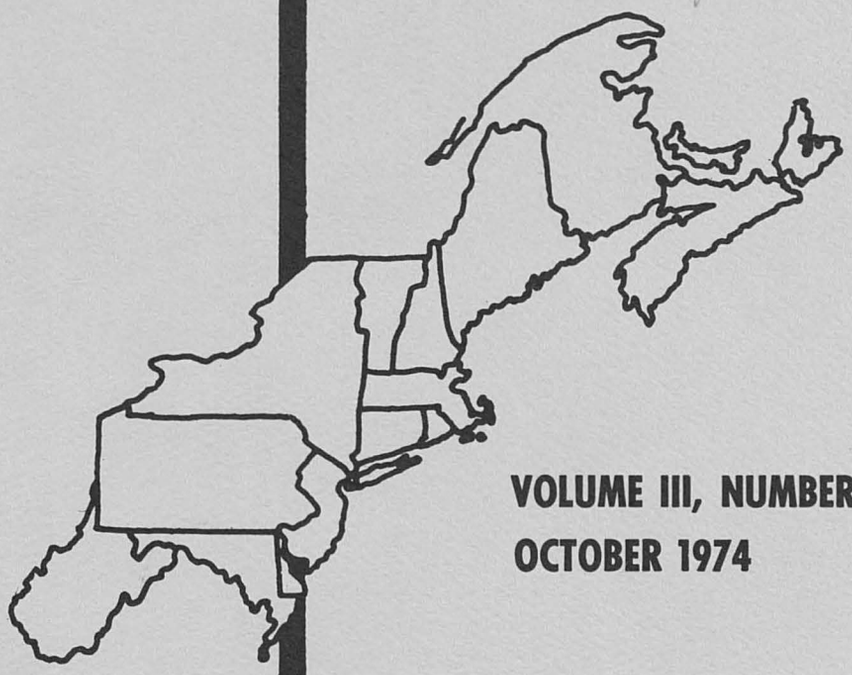

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HIGH DENSITY APPLE PLANTING SYSTEMS

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The Setting

Historically, the standard tree set in commercial apple orchards has been 27 trees per acre, planted on 40 foot centers. With this planting system trees tend to become quite large, requiring substantial amounts of labor for pruning, spraying and harvesting. The large amount of vegetative growth on these trees renders much of the inner-tree fruit bearing surface unproductive due to shading.

In an attempt to improve orchard efficiency, size-controlling rootstocks and closer tree spacings have been utilized in the past 10 years. In Western New York, for example, almost 40 percent of the apple trees in commercial orchards were classified "dwarf" or "semi-dwarf" in 1970. Almost 90 percent of these trees had been planted since 1960. Today, planting densities of 100 to 200 trees per acre are not uncommon.

Recent developments in rootstock technology have resulted in increased interest in even higher density planting systems as a vehicle for lowering apple production costs, improving fruit quality and increasing yields per acre. Using proper management techniques, apple production in high density orchards on size-controlling rootstocks offers the following advantages over standard seedling trees:

1. Earlier fruit bearing;
2. More bearing surface per acre and thus higher yields per acre;
3. Better spray penetration, air movement and light penetration, leading to improved fruit quality;
4. Less vegetative growth and therefore lower labor requirements for pruning, brush removal and harvesting; and
5. More potential for the adoption of mechanical orchard equipment, particularly mechanical harvesters.

The major disadvantages of the high density plantings include:

1. Large investment requirements for trees and in some instances tree supports (poles or wire trellis);

2. High level of skills required to properly manage the orchard;

3. The small number of varieties which are adaptable to the very high density plantings on existing rootstocks; and

4. Risk of excessive vegetative growth and inter-tree competition resulting from a crop failure.

The degree of dwarfing attainable from size-controlling rootstocks varies from severe to negligible. Similarly, tree density may range from 75 trees per acre to as many as 3,000 trees per acre. Because of the limited experience with the higher density plantings, there is no consensus of opinion as to the optimum degree of dwarfing or tree density required to maximize orchard returns.

Four Planting Systems

The purpose of this study was to estimate the investment requirements, production costs and returns for four alternative planting systems - Low Density, Medium Density, High Density and Ultra High Density. Data from existing blocks of apples were utilized in this analysis. However, these blocks lacked uniformity in tree density, rootstocks, varieties and planting dates. The methodology, therefore, involved utilizing actual cost and yield data to construct a "typical" orchard for each of the four planting systems.

As defined for this study, the Low Density planting system consists of 121 trees per acre, spaced 15' x 24'. Vigorous understock such as MM106 and MM111 are used and individual trees are free-standing. Medium Density plantings consist of 218 free-standing trees per acre (11' x 18' spacing) on understock such as M7 and M26 or on more vigorous rootstocks with M9 as an intermediate stempiece. The High Density system is planted at the rate of 454 trees per acre, spaced 8' x 12'. Only M9 and interstem M9 using an MM106 rootstock are suited to this density. It is assumed that the trees are supported by a wire trellis. The Ultra High Density system consists of 792 trees per acre on M9 rootstock, spaced 5' x 11'. Each tree is individually supported by a pole. For each planting system it is assumed that fresh apple varieties are produced, but only small growing varieties such as Golden Delicious, Idared and Jonathan are suited to the High and Ultra High Density systems.

The costs of apple production were analyzed in two categories: (1) establishment and development costs and (2) annual production costs. Establishment and development costs include all those costs incurred before the orchard begins to bear fruit. Annual production costs include those costs incurred in growing and harvesting apples once the orchard has reached bearing age. Direct financial expenditures and input-output information were obtained from 17 existing orchards (Table 1). Inputs were valued on the basis of estimated market value at the time the study was completed (1972). Equipment costs per hour of operation were also established for each operation (Table 2). All equipment rates were based on the size and type of equipment commonly utilized in Western New York and include overhead as well as operating costs.

Table 1
Cost of Materials

Item	Cost
Land	$500.00/acre
Trees	1.65 each
Poles (for Ultra High Density)	.81 each
Poles (for High Density)	1.50 each
Wire (for High Density)	9.00/1,000 foot
Herbicide - dymid	20.00/acre
- simazin	12.00/acre
Mousebait	3.00/acre
Tree guards	.15 each
Ties	25.00/1,000
Spray - Low Density	80.00/acre - full schedule
- Medium Density	80.00/acre - full schedule
- High Density	45.00/acre - full schedule
- Ultra High Density	40.00/acre - full schedule
Seed - Fescue	1.00/pound
Fertilizer	100.00/ton
Labor	3.00/hour
Capital	8% interest

Table 2
Hourly Equipment Rates for Apple Production

Operation	Tractor Cost Per Hour	Implement Cost Per Hour	Total Cost Per Hour
Plowing and fitting	$2.15	$ .50	$2.65
Marking	2.15	.15	2.30
Planting	2.15	.30	2.45
Pole setting	2.15	.15	2.30
Stringing wire	2.15	--	2.15
Cultivating	2.15	.25	2.40
Hoe (mech.)	2.15	1.25	3.40
Mow	2.15	.20	2.35
Spraying and herbicide	2.15	5.00	7.15
Seeding	2.15	.25	2.40
Mousebait	2.15	.20	2.35

Establishment and Development Costs

Estimated orchard establishment and development costs are summarized in Table 3. Included in the initial establishment costs are land costs, land preparation, planting and the cost of trees and supports. The cost of trees and supports accounts for approximately 90 percent of the difference in establishment costs for the four planting systems. Development costs include charges for cultivation, weed, insect and disease control, pruning, fertilizing, and overhead costs. An additional cost for mouseguards is incurred by the High and Ultra High Density plantings. Except for the total cost of trees, the non-bearing costs are essentially the same for the Low and Medium Density planting systems. Although only two years are required for the development of High and Ultra High Density plantings, total non-bearing costs are substantially larger than for the Low and Medium Density systems.

Table 3
Estimated Establishment and Development Costs Per Acre
Four Planting Systems

Item	Low Density	Medium Density	High Density	Ultra High Density
Initial Establishment				
Land	500	500	500	500
Labor a/	54	66	152	195
Machine & equipment	25	29	50	66
Materials	200	360	1,115	1,949
Other b/	10	10	10	10
TOTAL	789	965	1,827	2,720
First Year Development				
Labor a/	21	24	42	86
Machine & equipment	19	20	33	31
Materials	13	13	103	178
Other b/	20	20	20	20
TOTAL	73	77	198	315
Second Year Development				
Labor a/	32	32	59	169
Machine & equipment	29	29	34	34
Materials	38	38	43	29
Other b/	20	20	20	20
TOTAL	119	119	156	252
Third Year Development				
Labor a/	41	41	--	--
Machine & equipment	34	34	--	--
Materials	82	82	--	--
Other b/	20	20	--	--
TOTAL	177	177	--	--
TOTAL NON-BEARING COSTS	1,158	1,338	2,181	3,287

a/ Charged at $3.00 per hour.

b/ Overhead costs.

Annual Growing and Harvesting Costs

Estimated annual growing costs for each of the planting systems are summarized in Table 4. The second year of production is assumed to be typical in terms of growing costs, with relatively little variation in growing costs per acre among the four systems. There are, however, differences in the magnitude of the individual components of total costs. Materials costs are higher for the Low and Medium plantings because of lower spray efficiency; labor requirements are greater for the High and Ultra High Density systems reflecting the fact that many trees must be re-tied to supports at the time of pruning. Labor requirements for the pruning operation are actually lower for the High and Ultra High Density plantings than for the Low and Medium Density plantings.

In order to estimate apple harvesting costs per acre, estimates of yields were required. Yield estimates for Low Density plantings were based on records from 12 blocks of trees which were in their sixth year of production. Records of production were available on five blocks of Medium Density plantings which had been in bearing from 3 to 8 years. Yield data for High and Ultra High Density planting systems are not plentiful. Only two blocks of High Density orchards in Western New York had records of production. While production records were available on 10 blocks of Ultra High Density plantings, six were in production for the first year and four were only in the second year of production.

Yield estimates and harvesting costs are summarized for the first four bearing years for each planting system (Table 5). The fourth bearing year was assumed to represent a typical yield for the mature orchard with total harvesting costs, per bushel, in the fourth year of production estimated at $.46 for each planting system.

Table 4
Estimated Annual Growing Costs Per Acre
Four Planting Systems

Item	Low Density	Medium Density	High Density	Ultra High Density
	- - - - - - - - - $ Per Acre - - - - - - - - -			
First Bearing Year				
Labor a/	53	68	80	88
Machine & equipment	43	44	63	56
Materials b/	105	105	93	88
Other c/	40	40	40	40
TOTAL	241	257	276	272
Second Bearing Year (typical)				
Labor a/	77	86	116	106
Machine & equipment	44	44	59	51
Materials b/	105	105	81	70
Other c/	40	40	40	40
TOTAL	266	275	296	267

a/ Charged at $3.00 per hour.

b/ Includes spray, herbicides, mousebait, fertilizer and tying materials.

c/ Includes a charge for management and other overhead costs.

Table 5
Estimated Apple Yields and Harvest Cost Per Acre
Four Planting Systems

Item	Low Density	Medium Density	High Density	Ultra High Density
First Year - Yield	70	80	150	350
Picking a/	$ 25	$ 28	$ 53	$123
Other labor b/	3	3	6	12
Equipment & truck	4	4	8	16
Overhead	2	2	4	9
TOTAL	$ 34	$ 37	$ 71	$160
Second Year - Yield	130	150	500	625
Picking	$ 46	$ 53	$175	$219
Other labor	6	6	18	24
Equipment & truck	8	8	24	32
Overhead	4	4	13	16
TOTAL	$ 64	$ 71	$230	$291
Third Year - Yield	400	400	625	700
Picking	$140	$140	$219	$245
Other labor	15	15	24	27
Equipment & truck	20	20	32	36
Overhead	11	11	17	18
TOTAL	$186	$186	$292	$326
Fourth Year c/ - Yield	550	650	750	950
Picking	$192	$228	$263	$333
Other labor	21	24	27	36
Equipment & truck	28	32	36	48
Overhead	13	17	20	25
TOTAL	$254	$301	$346	$442

a/ Charged at $.35 per bushel.

b/ Charged at $3.00 per hour.

c/ Assumed to be "typical."

Table 6
Estimated Net Returns, Discounted Net Returns and Net Present Value
Four Planting Systems

Planting Year	Discount Factor a/	Low Density		Medium Density		High Density		Ultra High Density	
		Net Returns	Discounted Net Returns	Net Returns	Discounted Net Returns	Net Returns	Discounted Net Returns	Net Returns	Discounted Net Returns
		-$ Per Acre-							
1	1.00	-862 b/	-862	-1,042 b/	-1,042	-2,025 b/	-2,025	-3,035 b/	-3,035
2	.93	-119	-111	-119	-111	-156	-145	-252	-234
3	.86	-177	-152	-177	-152	-46	-40	356	306
4	.79	-152	-120	-154	-122	474	374	848	670
5	.74	-101	-75	-83	-61	662	490	982	727
6	.68	249	169	239	163	858	583	1,429	971
7	.63	444	280	562	354	858	541	1,429	900
8	.58	444	258	562	326	858	498	1,429	829
9	.54	444	240	562	303	858	463	1,429	772
10	.50	444	222	562	281	858	429	1,429	715
11	.46	444	204	562	259	858	395	1,429	657
12	.43	444	191	562	242	858	369	1,429	614
13	.40	444	177	562	225	858	343	1,429	572
14	.37	444 b/	164	562 b/	208	858 b/	317	1,429 b/	529
15	.34	944 b/	320	1,062 b/	361	1,358 b/	462	1,929 b/	656
Net Present Value			905		1,234		3,054		5,649

a/ 8% discount rate.

b/ Includes $500 land value.

Profitability

Discounted cash flow techniques were used to evaluate the relative profitability of each of the planting systems. Based on the cost and yield estimates derived above, net returns and discounted net returns can be calculated for each year for the life of the orchard. Unfortunately, most of the high density planting systems used in this study have been in existence only a relatively short period of time and their productive life is not known with certainty. Initially, the Net Present Value of each planting system was calculated for a 15 year period, assuming a price of $1.75 per bushel of apples produced in Low and Medium Density orchards, $2.00 for High Density and $2.25 for Ultra High Density orchards 1/(Table 6). Assuming that at the end of the 15 year period, the orchard had no value beyond the value of the land, Net Present Value was found to increase as tree density increased. The computed Net Present Value for the Ultra High Density system was more than six times that of the Low Density system.

There is some consensus of opinion that the life of the Low and Medium Density systems may, in fact, be substantially longer than that of the High and Ultra High Density systems. An additional computation of Net Present Value was made for a thirty year period under the following assumptions:

(a) The life of the Low and Medium Density systems is 30 years, with no salvage value, other than land value, at the end of this time;

(b) The life of the High and Ultra High Density systems is 15 years. It is assumed that the orchard is removed after the 15th season at a cost of $200 per acre, is left idle one year and replanted in the Spring of the 17th year.

Net Present Values computed for the 30 year period are $2,092, $2,755, $3,645 and $6,951 per acre for the Low, Medium, High and Ultra High Densities, respectively. Under these assumptions, the performance of the Low and Medium Density systems improves relative to the High Density system. The absolute advantage of the Ultra High Density system, however, is increased.

Net Present Value computations presented here are based on the assumption that orchard performance remains constant from the time of maturity to the time of replacement. Evidence from existing standard

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1/ Price differentials reflect quality differences actually recorded.

orchards indicates that this is likely not the case; that in fact, yield may decline and costs increase after a certain age. However, there is no evidence that decline in performance among planting systems varies more than that accounted for by the replant assumption for the High and Ultra High Density systems. If this is the case, the relative position of the four systems is not affected by the assumption of constant performance.

Conclusions

Recent events indicate that orchards consisting of old, standard apple trees may not provide sufficient opportunity to improve fruit quality, color and size, or to improve production efficiency to the extent required for apple growers to remain viable in the long run. This study indicates that increased tree density on size-controlled rootstocks may result in increased profitability of the apple orchard. Analysis shows that orchard returns increase as tree density increases and tree size decreases. However, the investment requirements and managerial skills necessary for successful production also increase as tree density increases. Furthermore, not all growing conditions are suitable for the higher density plantings and at the present time only a limited number of apple varieties are adaptable to these very intense growing conditions. Farmers who are considering the replacement of older orchards, or the establishment of new plantings, will have to consider their own managerial talents and capital position as well as the suitability of available sites in determining the proper planting system.