JULY 1980
BULLETIN 519

Pruning and Training of Red Delicio Apples

GRICULTURAL EXPERIMENT STATION

AUBURN UNIVERS

CONTENTS

FIRST PRINTING 4M, JULY 1980

Pruning and Training of Red Delicious Apples

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TWO MAJOR PROBLEMS confronting the apple industry are increasing cost of production and a lack of qualified workers, particularly for pruning and harvesting operations *(2,3,5)*. Kelsey *(11)* reported in 1971 that pruning accounted for over 30 percent of apple production cost. This has probably increased since then, since labor available for pruning has decreased and become more expensive. Smith and Feree *(14)* reported that time required for tree training accounted for 43 percent of the preharvest labor requirements. In an effort to improve pruning efficiency and reduce cost, research with various mechanical pruners has been conducted by a number of research workers *(2,3,5,6,8,9)*. Even though the use of mechanical cutter bars to hedge and top trees reduces time necessary to prune orchards, such pruning results in a dense periphery of vigorous shoot growth. This dense growth reduces light penetration into the canopy, which results in suppressed spur formation, spur death, and poorly colored, small fruit *(2,3,5)*. Mechanical pruning plus supplemental hand pruning has been an effective method *(6,9)*, but the effect of annual mechanical pruning on yield has not been investigated.

McBirney *(12)* reported that picking rate by fruit harvesters decreased by 0.4 bushel per hour for each 1-foot increase in bearing height of the tree. Thus, a picker would harvest 4 bushels per hour less from a 20-foot high tree than from a 10-foot high tree. Gilbert *(7)* reported that Auvil has successfully grown trees at

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close spacing to a 14-foot height and then maintained the trees thereafter at this height by removing all annual terminal growth. He has produced 2,000 bushels per acre each year using this method, which is known as the "mold and hold" system.

Research to determine the effect of pruning treatments and row spacing on yield and tree performance was initiated by the Auburn University Agricultural Experiment Station at its Chilton Area Horticulture Substation, Clanton, and Piedmont Substation, Camp Hill.

PRUNING EXPERIMENT

The pruning study was established on Vance Red Delicious apples in their ninth leaf on MM106 rootstock. The trees were trained to a modified central leader at a spacing of 15 feet by 20 feet and had formed a solid wall in the row. All trees were hand pruned at the onset of the experiment. Treatments consisted of (1) mechanical pruning annually, (2) mechanical pruning plus detailed hand pruning annually, (3) hand pruning annually, and (4) mechanical pruning annually plus hand pruning the first, third, and fifth years. Each treatment was replicated four times

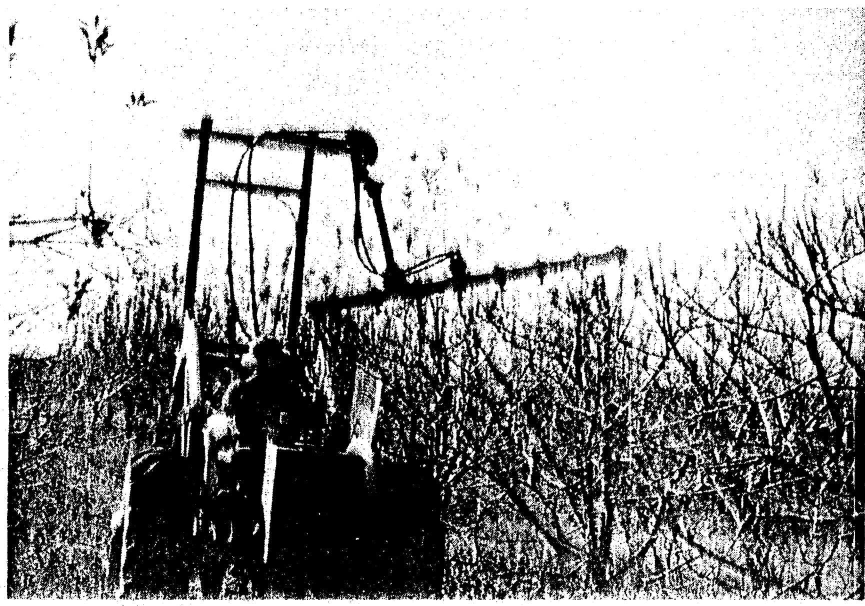

FIG. 1. A Fossum tree pruner mounted on front of tractor.

in a randomized complete block design with 10 trees per replication.

Mechanical pruning was done with a Fossum tree pruner mounted on the front of a tractor, figure 1. The pruner blade was set at an 80° angle so that each side of the tree top was cut at a slant, upward to the center. The blade was positioned so that the previous year's growth was removed. Conventional hand pruning techniques were used to maintain a modified central leader on hand pruned treatments. The time necessary to do both the mechanical and hand pruning was recorded. Tree fruiting height was maintained at 8 feet, conforming to growers' desire to maintain a fruiting height that would allow harvesting without the use of ladders.

Light readings were taken in 1974 with a Weston Model 756 sunlight illumination meter in the center of the tree at depths of 1, 2, 3, and 4 feet below the canopy surface. Similar readings were taken near the outer periphery of the limb spread.

Recommended practices for fertilization and insect, disease, and weed control were followed *(4,15)*. Fruit were thinned with 2 pounds of Sevin per 100 gallons of spray solution 21 days after full bloom, followed by hand spacing and thinning of clusters.

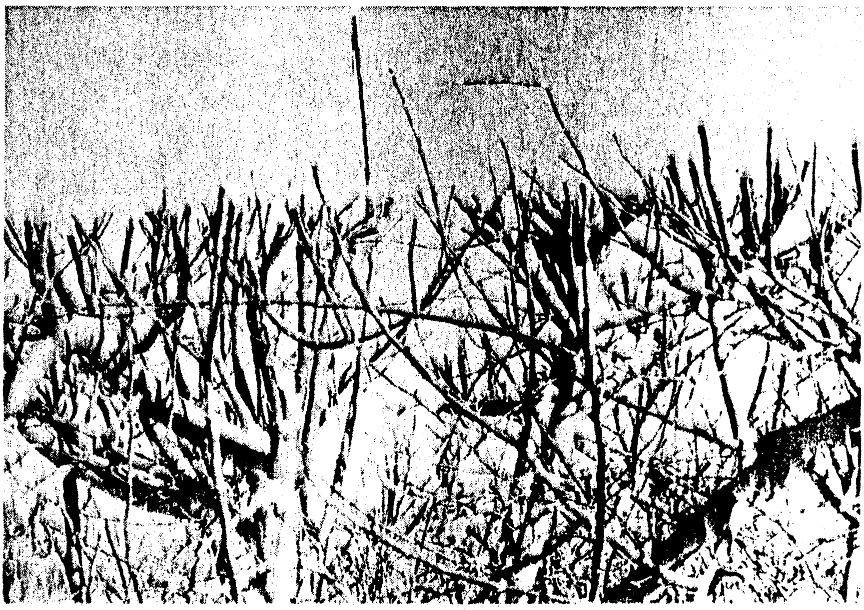

FIG. 2. A large number of shoots developed near each cut made with the mechanical pruner. This resulted in a thick canopy which prohibited light penetration.

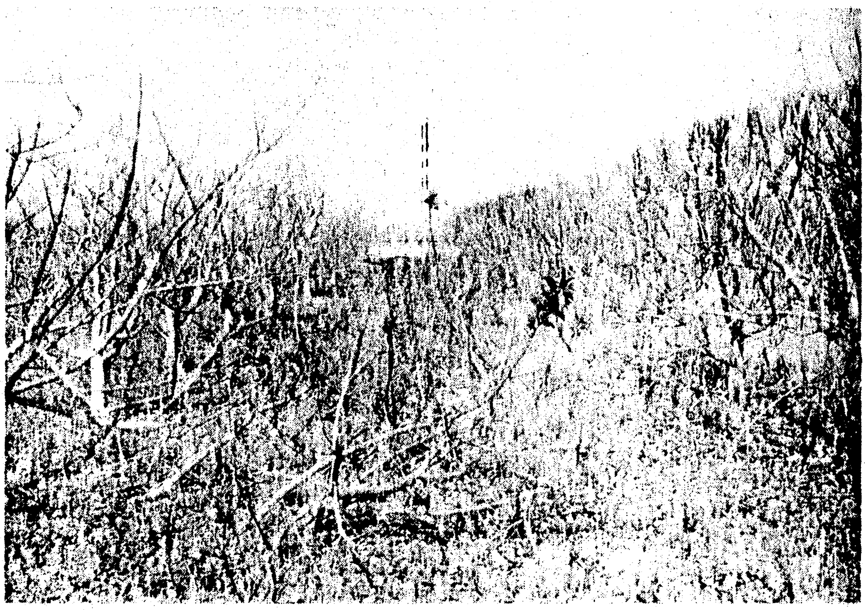

FIG. 3. Row of trees on right was mechanically pruned only each year, whereas trees on the left were hand pruned following mechanical pruning each year. Hand pruning following mechanical pruning opened up the tree by removing excess shoot development.

Results and Discussion

Use of the mechanical pruner destroyed the desired shape and framework of the tree. As many as 8-10 shoots developed around each cut made by the mechanical pruner if detailed hand pruning did not follow, figure 2. Mechanical pruning alone resulted in trees with a thick canopy which suppressed spur formation, shaded out fruiting wood in the interior of the tree, made insect and disease control difficult, and prevented fruit from developing red color, figure 3.

A combination of mechanical and hand pruning each year reduced pruning time over that of hand pruning alone, table 1. Mechanical pruning prior to hand pruning reduced the time required to hand prune by 40, 39, 22, and 32 percent, respectively, in the 2nd, 3rd, 4th, and 5th years. The plots which were mechanically pruned each year and hand pruned in alternate years did not differ in time required to hand prune in alternate years (years 3 and 5) from the hand pruned only treatments. However, the hand pruning time was reduced approximately 50 percent over the 4

TABLE 1. EFFECT OF MECHANICAL PRUNING ON TIME REQUIRED TO PRUNE VANCE RED DELICIOUS APPLE TREES ON MM 106 ROOTSTOCK

Treatment	Time per replication (10 trees)[1]									
	1972		1973		1974		1975		1976	
	Hand	Machine	Hand	Machine	Hand	Machine	Hand	Machine	Hand	Machine
	Min.	*Min.*	*Min.*	*Min.*	*Min.*	*Min.*	*Min.*	*Min.*	*Min.*	*Min.*
Mechanical prune only	104 a[2]	5.5 b	0 a	3.3b	0 a	3.2 a	0 a	3.7 b	0 a	3.7 b
Mechanical prune plus hand prune	113 a	4.3 b	149 b	3.1 b	163 b	3.2 a	232 b	3.3 b	240 b	3.4 b
Hand prune only	148 b	0 a	249 c	0 a	266 c	0 a	296 c	0 a	355 c	0 a
Mechanical prune annually plus hand prune 1st, 3rd, and 5th years	111 a	4.8 b	0 a	3.0 b	271 c	2.5 a	0 a	3.5 b	315 bc	3.3 b

[1]Experimental trees were established in 1964 and were in their ninth leaf at the initiation of the experiment in 1972.
[2]Mean separation, within columns, by Duncan's multiple range test, 5 percent level.

years due to alternate year pruning. Time necessary for mechanical pruning did not vary between mechanically pruned treatments.

Yield was not significantly affected by pruning methods, table 2. The general trend was for mechanically pruned plus hand pruned trees (treatments 2 and 4) to produce higher yields than either hand pruned or mechanically pruned trees.

TABLE 2. EFFECT OF PRUNING METHOD ON YIELD OF VANCE RED DELICIOUS APPLE TREES ON MM 106 ROOTSTOCK

Treatment	Yield per tree[1]				
	1972	1973	1974	1975	1976
	Lb.	*Lb.*	*Lb.*	*Lb.*	*Lb.*
Mechanical prune only	126 a[2]	174 a	158 a	128 a	157 a
Mechanical prune plus hand prune	118 a	160 a	192 a	170 b	227 a
Hand prune only	106 a	142 a	140 a	136 ab	189 a
Mechanical prune annually plus hand prune 1st, 3rd, and 5th years	126 a	180 a	190 a	160 ab	223 a

[1]The experimental trees were established in 1964 and were in their ninth leaf at the initiation of the experiment.
[2]Mean separation, within columns, by Duncan's multiple range test, 5 percent level.

Light penetration into the center of hand pruned trees was 4-10 times greater than for mechanically pruned only trees, table 3. Small differences were recorded for light penetration into the branches on the outer periphery of the tree. The heavy pruning necessary to maintain the trees at an 8-foot fruiting height was too severe and resulted in excessive vegetative growth each season. In a different experiment in which the same age scion-rootstock combination was mechanically pruned, trees reached a bearing height of 14-16 feet before excessive vegetative growth was arrested and large annual crops were produced.

The time required to hand prune was reduced by use of the mechanical pruner prior to hand pruning, and yield was not adversely affected. However, this investigation indicates that mechanical pruning to maintain an 8-foot fruiting height is not satisfactory for high density orchards in Alabama due to effects on color development, light penetration, and tree shape. The results may have been different had a greater fruiting height been maintained.

TABLE 3. INFLUENCE OF PRUNING METHOD ON LIGHT PENETRATION INTO VARIOUS DEPTHS OF TREE CANOPY[1]

Treatment	Light readings at various positions in tree canopy, foot candles				
	Top of canopy	1 foot	2 feet	3 feet	4 feet
JUNE 17			Center		
Mechanical prune only	10,562.5	450.0	262.5	125.0	131.3
Mechanical prune plus hand prune	10,550.0	2,425.0	850.0	850.0	375.0
Hand prune only	10,450.0	4,475.0	1,250.0	775.0	675.0
Mechanical prune annually plus hand prune 1st, 3rd, and 5th years	10,050.0	1,562.5	312.5	256.3	100.0
			Outer periphery		
Mechanical prune only	10,550.0	3,875.0	2,075.0	837.5	287.5
Mechanical prune plus hand prune	10,675.0	2,812.5	1,325.0	675.0	650.0
Hand prune only	10,362.5	4,650.0	637.5	237.5	212.5
Mechanical prune annually plus hand prune 1st, 3rd, and 5th years	10,025.0	2,887.5	750.0	287.5	175.0
JUNE 27			Center		
Mechanical prune only	9,900.0	875.0	387.5	275.0	162.5
Mechanical prune plus hand prune	9,737.5	1,787.5	725.0	962.5	275.0
Hand prune only	9,737.5	1,287.5	900.0	1,537.5	650.0
Mechanical prune annually plus hand prune 1st, 3rd, and 5th years	9,950.0	350.0	212.5	131.3	275.0
			Outer periphery		
Mechanical prune only	9,825.0	3,487.5	1,150.0	500.0	312.5
Mechanical prune plus hand prune	9,775.0	5,550.0	2,412.5	1,212.5	400.0
Hand prune only	9,800.0	3,625.0	1,150.0	537.5	1,012.5
Mechanical prune annually plus hand prune 1st, 3rd, and 5th years	9,750.0	2,725.0	1,675.0	775.0	437.5

[1]Light readings obtained with Weston Model 756 sunlight illumination meter. Readings were made above the tree canopy and at depths of 1, 2, 3, and 4 feet from the top of the canopy at both the center and in the outer periphery.

TREE SPACING AND LIMB POSITIONING EXPERIMENT

Wellspur Red Delicious apple trees on MM 106 rootstock were planted in January 1969 with spacings of 5, 7.5, and 10 feet between trees in the row and 22 feet between rows. Trees were trained to a modified central leader with major scaffold branches developed at a 65- to 90-degree angle to the trunk axis by the use

FIG. 4. Branches were placed in a horizontal position by pulling them down and tying them in position.

of wire braces during the first few years of the tree's life. In the spring of 1973 the trees were topped at a height of 8 feet with a Fossum tree pruner, followed by uniformly detailed pruning by hand. The 5-foot spaced trees had formed a solid tree wall at this time.

A randomized complete block design with four replications of 5-tree plots was utilized to determine how tree spacing, conventional training, and horizontal placement of all major scaffold branches affected weight and number of fruit produced. With trees spaced 7.5 and 10 feet, branches were placed in a horizontal position by pulling down and tying them in position, figure 4. Weight and number of fruit per tree were recorded from 1974 through 1979. No yield records were recorded in 1978 due to poor fruit set.

Results and Discussion

The accumulated yield was higher for 5-foot spaced trees than 7.5- and 10-foot spaced trees on which the major scaffold branches were not spread, table 4. However, the 10-foot spaced trees with major scaffold branches spread had an accumulated

TABLE 4. EFFECT OF TREE SPACING AND LIMB POSITIONING ON YIELD OF WELLSPUR RED DELICIOUS APPLE TREES ON MM106 ROOTSTOCK

Treatment of major scaffold branches	Yield per acre, by year					Accumulated yield/acre
	1974	1975	1976	1977	1979	
	Bu.	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Bu.*
10-ft. spacing in row[1]						
Tied[2]	256 b[3]	313 bc	346 a	538 b	1,004 a	2,457 a
Not tied	217 b	275 c	305 a	409 b	953 ab	2,159 b
7.5-ft. spacing in row						
Tied	369 a	428 a	410 a	391 b	688 bc	2,286 b
Not tied	260 b	360 abc	297 a	404 b	666 bc	1,987 c
5-ft. spacing in row						
Not tied	464 a	391 ab	353 a	815 a	508 c	2,531 a

[1]Trees spaced 5, 7.5, and 10 feet apart in the row equals 396, 264, and 198 trees per acre, respectively.

[2]The major scaffold branches present on the 5-year-old central leader trees were tied to a horizontal position at the initiation of the experiment. The not-tied treatment consisted of trees that were trained to a central leader and the major scaffold branches were not tied to a horizontal position.

[3]Mean separation, within columns, by Duncan's multiple range test, 5 percent level.

yield equal to the 5-foot spaced trees. Limb spreading increased the accumulated yield of the 7.5- and 10-foot spaced trees by approximately 300 bushels per acre.

The 5-foot spaced trees produced higher yields in the early years, but the 10-foot spaced trees produced more in 1979. The number of fruit produced per acre followed the same trend as the

TABLE 5. EFFECT OF TREE SPACING AND LIMB POSITIONING ON NUMBER OF FRUIT PRODUCED PER ACRE BY WELLSPUR RED DELICIOUS APPLES ON MM106 ROOTSTOCK

Treatment of major scaffold branches	Number fruit/acre, by year				
	1974	1975	1976	1977	1979
	No.	*No.*	*No.*	*No.*	*No.*
10-ft. spacing in row[1]					
Tied[2]	28,789 b[3]	35,155 bc	31,314 a	66,904 b	113,078 ab
Not tied	26,245 b	28,898 c	25,610 a	49,179 b	109,065 ab
7.5-ft. spacing in row					
Tied	43,904 ab	48,075 a	37,224 a	54,138 b	83,768 b
Not tied	29,898 b	36,458 bc	25,610 a	50,517 b	82,131 b
5-ft. spacing in row					
Not tied	59,697 a	42,234 ab	30,427 a	108,445 a	142,447 a

[1]Trees spaced 5, 7.5, and 10 feet apart in the row equals 396, 264, and 198 trees per acre, respectively.

[2]The major scaffold branches present on the 5-year-old central leader trees were tied to a horizontal position at the initiation of the experiment. The not-tied treatment consisted of trees that were trained to a central leader and the major scaffold branches were not tied to a horizontal position.

[3]Mean separation, within columns, by Duncan's multiple range test, 5 percent level.

TABLE 6. EFFECT OF TREE SPACING AND LIMB POSITIONING ON AVERAGE WEIGHT OF FRUIT PRODUCED BY WELLSPUR RED DELICIOUS APPLE TREES ON MM106 ROOTSTOCK

Treatment of major scaffold branches	Individual fruit weight, by year					Average fruit weight
	1974	1975	1976	1977	1979	
	Lb.	*Lb.*	*Lb.*	*Lb.*	*Lb.*	*Lb.*
10-ft. spacing in row[1]						
Tied[2]	0.360 a[3]	0.358 a	0.438 a	0.323 a	0.377 a	0.371 ab
Not tied	.360 a	.386 a	.474 a	.331 a	.351 a	.380 a
7.5-ft. spacing in row						
Tied	.349 a'	.356 a	.440 a	.290 a	.329 a	.353 b
Not tied	.337 a	.391 a	.449 a	.320 a	.322 ab	.364 ab
5-ft. spacing in row						
Not tied	.315 a	.371 a	.465 a	.300 a	.210 b	.332 b

[1]Trees spaced 5, 7.5, and 10 feet apart in the row equals 396, 264, and 198 trees per acre, respectively.

[2]The major scaffold branches present on the 5-year-old central leader trees were tied to a horizontal position at the initiation of the experiment. The not-tied treatment consisted of trees that were trained to a central leader and the major scaffold branches were not tied to a horizontal position.

[3]Mean separation, within columns, by Duncan's multiple range test, 5 percent level.

weight, table 5. Pruning method did not affect average fruit weight, table 6.

The 10-foot spacing is better for "spur type" trees on MM 106 rootstock than the 5- and 7.5-foot spacing. The closer spacing requires more plants per acre, and the 5-foot spaced trees soon become crowded and begin competing among themselves, figure 5. Major scaffold branch positioning develops a tree that has the potential for producing large crops in the future.

CONCLUSION

Results of the research reported emphasize the need to properly train and shape an apple tree in its early years and maintain this form for the duration of the orchard's productive life. Mechanical pruning destroyed the tree shape and led to the formation of a thick canopy, which prevented light penetration into the center of the tree pruned to an 8-foot height. Hand pruning developed a more desirable tree.

DISCUSSION AND RECOMMENDATIONS

Based on recorded results and observations made during the experiments, as well as on other available data, certain general statements and recommendations concerning apple tree training and pruning can be made.

FIG. 5. The 5-foot spaced trees were crowded and competing among themselves in the fifth growing season.

The ideal shape would have all leaves on the tree intercepting a maximum and equal amount of light. A perfect distribution of light would result in the vegetative growth being evenly distributed throughout the tree and fruit being of uniform size, quality, and maturity. In addition, the light intercepting leaf area and fruiting wood should be close to the ground to facilitate cultural practices and harvest. To achieve these goals, the growth pattern of the scion variety-rootstock combination must be considered when planning the orchard and the trees must be properly trained in the early years of the orchard's life.

The central leader tree form (pyramidal or Christmas tree) for free standing or staked medium density plantings of apples is preferred to maximize light penetration into the center of the tree and light distribution along and between trees, figure 6. Methods of training high density, free standing apple trees to a central leader system have been reported by several workers *(1, 10, 13)*. These methods, with modifications, were used in developing the following procedure for training free standing, high density apple trees and maintaining them.

FIG. 6. This is a well shaped spur type Red Delicious apple tree on MM106 rootstock in the third growing season. The first two tiers of branches have been developed.

Newly set trees should be pruned immediately after planting, before growth begins, to a height of 28 to 30 inches. This will force the first scaffold branches to develop at the desired height. When the new branches are 3 to 6 inches long, remove all branches lower than 20 inches above the soil line. Three to five branches that are 2 to 6 inches apart and spiraling up and around the tree should be selected, with all other lateral branches removed by rubbing them off. The selected branches will form the first tier or whorl of branches. Train the selected branches to form a wide crotch angle by using spring-type wooden clothespins, round toothpicks, or short wires (number 9 clothes line wire) sharpened at both ends, figures 7, 8, and 9. The braces should be put in when the branches are 3 to 6 inches long and set so that the branches form a 90-degree angle with the main axis of the tree.

Remove the clothespins to prevent girdling when shoot tissue

FIG. 7. Wooden clothespins can be used to develop the initial branch angle of 90°.

FIG. 8. Round wooden toothpicks can be used to develop the proper branch angle.

lignifies or hardens, usually by mid-July in the same season. It should be noted that clothespins or other small devices are initial training aids and not substitutes for long limb spreaders to be used later. The toothpicks and wire braces do not have to be removed that season. All other branches that develop in this area should be removed when they begin growing so they do not compete with the selected scaffold branches. This will develop the first tier of branches.

Three or four tiers of branches will usually be needed to form the ideal tree. The second, third, and fourth tiers should be at least 20 to 24 inches apart on spur type trees and 24 to 36 inches apart on non spur type trees. It will take 3 to 4 years to develop the third- or fourth-tier branches. The procedure used to develop the first tier of branches should be used to develop the second, third, and additional tiers of branches. When a tier of branches is selected and formed, the terminal of the leader should be removed about 36 inches above this tier to facilitate branch development for the next tier. All branches should be removed as they start to develop between the tiers of branches.

When developing the second and higher tiers, shoots should be selected that have an area of their own to intercept light without casting excessive shade on lower limbs. To accomplish this, the

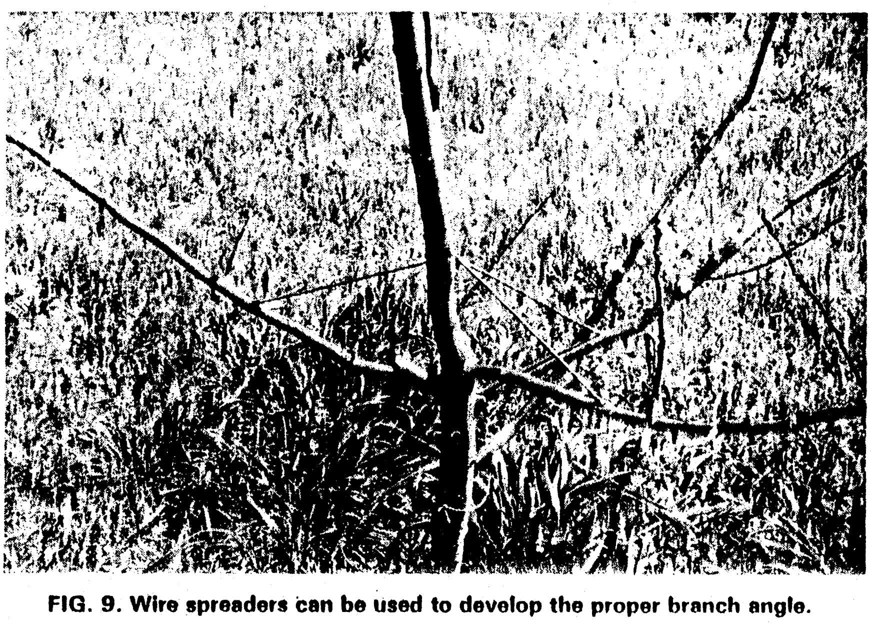

FIG. 9. Wire spreaders can be used to develop the proper branch angle.

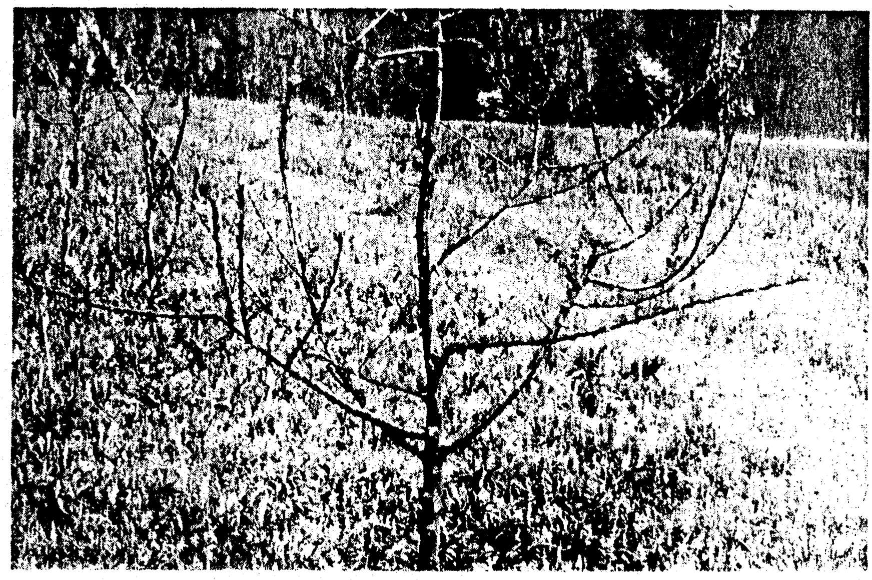

FIG. 10. This is a well trained 3-year-old tree with two tiers of branches developed. The branches in the second tier are positioned between and not directly above a branch in the lower tier, so that shading is minimized.

branches in the tier above another should be positioned between and not directly above a branch in the lower tier, figure 10.

The branches that were forced to form a wide angle at their bases will turn and grow upward as they elongate. Thus, after clothespins are removed from newly formed scaffolds (in mid-summer of the first year), it is usually advantageous to continue the branch spreading process using longer spreaders. If trees have made sufficient growth, new spreaders may be placed on branches in late summer of the first growing season. Otherwise, new spreaders should be positioned on branches during the first winter. Tree development will dictate when additional spreading should be done. Branches should be initially braced to form a 35- to 45-degree angle with the main axis of the tree. Spreading the limbs to a more horizontal position at this time encourages the development of undesirable, strong, vertical shoots on the tops of scaffold limbs. As branches become large enough to fill their allotted space, they may be spread further to about a 60-degree angle from the central leader. The branches can be spread using wood spreaders, wire spreaders, or wires, figure 11. Spreaders will need to be used for one and possibly two or more seasons.

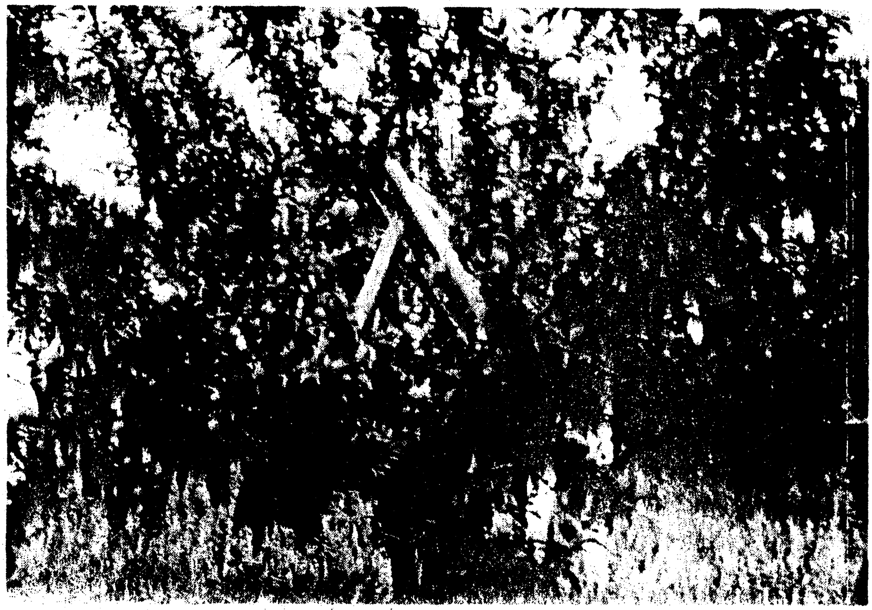

FIG. 11. Wood spreaders can be used to improve the crotch angle on larger limbs.

Suckers arising from trunk and scaffold branches should be removed two or three times during the growing season by rubbing the tender shoots off.

In some instances a side branch will not develop at the desired location on the trunk of a tree. If a scaffold branch is needed in a particular spot on the tree, you can force a dormant bud by making a 1-inch cut through the bark parallel to the ground, ½ inch above a bud on young trees and 1 inch above a bud on older trees, figure 12.

Apple trees trained by the above procedure will have a sufficient number of well placed scaffold branches. A maximum number of horizontal fruiting branches should be developed near the tree axis on each scaffold branch. If the fruiting branches are developed near the tree axis, this will eliminate the need to prop the scaffold branches when the tree starts producing heavy loads. Fruiting spurs should be developed from the sides of the horizontal fruiting branches. The fruiting spurs developing from the sides of the fruiting branches are more productive and produce larger, higher colored fruit. Fruiting spurs that develop on the lower side of the branch are weak and produce small, less colored fruit. Fruiting spurs that develop from the top of the branch are less productive, more vigorous, and subject the fruit to limb rub and sunburn.

Annual pruning of bearing trees is essential throughout the lifetime of an orchard. The introduction of size controlling rootstocks and the pyramidal form for tree training has resulted in changes in the conventional manner in which bearing trees are pruned. The need to prune trees in high density plantings to maintain them within their allotted space is considerably more important than with larger trees grown on wider spacings. Tree vigor must be kept adequate, but not excessive, to produce optimum yields of top quality fruit. To achieve all of the desired effects from pruning higher density plantings requires a limited amount of summer and winter pruning annually. Summer pruning is more dwarfing than winter pruning, but both types are necessary in properly managing modern apple orchards.

Bearing apple trees should be pruned during the winter prior to bloom development. Pruning at this time is stimulative and should not be overdone to avoid excessive shoot growth in the spring. This form of pruning is quite useful for thinning out excessive limbs and reducing tree height while maintaining sufficient vigor in the tree top. It is important to maintain the central leader as a strong vegetative shoot on bearing trees. This is most easily achieved through annual heading back of the 1-year-old terminal portion each winter. Sometimes it may be necessary to leave only one or two buds of the previous year's growth. Trees on semi-dwarfing rootstocks (M7A and MM 106) can be main-

FIG. 12. If a scaffold branch is needed in a particular spot on the tree, a dormant bud can be forced by making a 1-inch cut through the bark parallel to the ground (arrow, left photo), ½ inch above a bud on young trees and 1 inch above a bud on older trees. Result of the cut is evident in the right photo (arrow points to old cut).

tained at a height of 14 to 16 feet and trellised trees at a 7- to 8-foot height through annual topping as just described. If the trees grow too high, too quickly, lower branches may not develop properly. To correct this situation, the top may be cut back substantially (in 2-year or older wood) during regular winter pruning. The idea is to develop vigor evenly throughout the tree in all scaffolds while keeping the tree in its allotted space.

During the training process, heading cuts are used to stiffen the central trunk and lateral scaffolds and cause more branching and spur development. As trees begin regular bearing, the number of heading cuts should be reduced. If lateral branches are long enough to fill the allotted space, the terminal shoot should not be headed back. A thinning cut should be used to reduce the vigorous terminal shoot to a weaker side or terminal shoot which should be left unheaded. The object is to discourage further growth in that area. Thinning cuts should be used to replace most heading type cuts in older bearing trees (except for the terminal of the central leader which must be headed annually). Some heading cuts will be needed to replace fruiting wood where growth has become too slow.

The thinning out and heading back cuts on the central leader and lateral scaffolds are among the most important aspects of winter pruning. Normally, excessive inside shoot growth is handled with summer pruning, but it still may be necessary to remove any undesirable shoot growth developing on the upper sides of branches and where crowding of branches is occurring. Large limbs which are crowding other scaffolds may be removed in the winter by cutting back to a side branch. Dead, diseased, weak, and unproductive wood should also be removed. It is important to keep the center of the tree around the trunk open to permit spray materials and light to better penetrate the tree. Do not leave stubs when pruning unless cuts are being made for spur development. Cut back to a lateral branch in the direction of desired growth.

Pruning during the growing season can dwarf or devitalize apple trees. The degree of dwarfing resulting from summer pruning is related to the amount of leaf area removed. Early season growth is produced at the expense of stored materials in the tree. After the leaf area has developed, carbohydrates manufactured in the leaves begin to feed back into the storage areas to be used during the following season. With summer pruning, leaf area is removed before the feedback process is complete. The later in the season that summer pruning is done, the more leaf area is removed and the greater is the dwarfing response.

Summer pruning is an important step in properly training young apple trees. It can be used to direct growth into desired growing points on young trees and actually result in larger and better shaped trees than non summer pruned trees. If summer pruning is done just after the shoots start to grow and are only a few inches long, little actual leaf area is removed.

Summer pruning can be used to direct growth into desired growing points in the following ways:

1. Shoots headed during the dormant season usually develop two or three vigorous shoots from buds immediately below the cut. One or two of these shoots can be removed early in the growing season to direct the growth into a single shoot.

2. After branches have been selected to form the scaffold branches for each tier, the remaining shoots in this area should be removed by rubbing off.

3. Shoots developing on the trunk between the tiers of branches should be removed just after they begin to develop.

FIG. 13. Spur and flower bud development occurs following summer pruning between July 15 and August 1.

4. When the major scaffold branches are braced out to the desired position, several strong shoots normally develop in the bend area on the upper side of the branch. These should be removed by rubbing prior to lignification.

5. Apical dominance can be broken on vigorous shoots by removing the terminal bud and thus promoting the development of side shoots.

Flower bud formation can be enhanced on current season's growth by pruning the shoots back to two or three lateral buds between July 15 and August 1, figure 13. After heading, the remaining buds will make short shoots that often form terminal flower buds. This practice is generally effective on young trees when strong upright shoots on the main scaffold and horizontal branches are headed back. However, heading back current season's shoots early in the growing season will usually result in the remaining lateral buds making excessive growth. In general, summer pruning in late July and early August will reduce growth and aid in developing a fruiting system for the following season.

Proper training and care of apple trees in the early years of the orchard's life will enable the grower to cope with labor shortages and increasing production cost in properly managing the orchard for production of quality fruit in later years. Properly trained trees will produce large, high quality crops at an earlier age than trees that are allowed to grow for several years and then trained. Trees that produce large crops at an early age make less vegetative growth, thus requiring less pruning and management in later years.

LITERATURE CITED

(1) BANTA, E. S., F. S. HOWLETT, AND R. G. HILL, JR. Pruning and Training Fruit Trees. Ohio State Univ. Ext. Bull. 528:1-24.

(2) CAIN, J. C. 1971. Effects of Mechanical Pruning of Apple Hedge Rows with a Slotting Saw on Light Penetration and Fruiting. J. Amer. Soc. Hort. Sci. 96:664-667.

(3) CAIN, JOHN C. 1972. Slotting Saw Pruning of Hedge Row Apples Improves Production and Quality. Cornell Univ. Food and Life Sci. Bull. 15:1-4.

(4) COPE, J. T. AND D. L. KIRKLAND. 1975. Fertilizer Recommendations and Computer Program Key Used by the Soil Testing Laboratory. Auburn Univ. (Ala.) Agr. Exp. Sta. Cir. 176.

(5) FERREE, D. C. 1976. Influence of Slotting Saw Mechanical Pruning and Alar on Apple Fruit Size and Quality. Ohio Agr. Res. and Dev. Center Res. Cir. 220:3-7.

(6) FORSHEY, C. G. 1970. Mechanical Hedging and Topping of Fruit Trees. Eastern Fruit Grower. Mar. 1970. p. 4.

(7) GILBERT, E. J. 1964. Mold and Hold a Profitable System of Pruning. American Fruit Grower. Mar. 1964. p. 18.

(8) HALSELY, D. G., C. D. MCCARTY, AND S. B. BOSEWELL. 1972. Desert Grapefruit Pruning and Orchard Thinning Trials. Calif. Agr. 26(3):7-9.

(9) HANSEN, C. F., R. P. LARSEN, AND G. MONROE. 1968. Hedge Pruning of Fruit Trees. Mich. Agr. Exp. Sta. Quart. Bull. 50:331-341.

(10) HEINICKE, DON R. 1975. High-density Apple Orchards—Planning, Training and Pruning. USDA Agr. Res. Ser. Agr. Handbook 458:1-34.

(11) KELSEY, M. P., S. B. HARSH, AND H. BETTER. 1971. Economics of Apple Production in Southwestern Michigan. Mich. State Univ., Agr. Econ. Rpt. No. 184.

(12) MCBIRNEY, S. W. 1968. It's True: Dwarf Trees Can Be Picked Faster. Western Fruit Grower. Aug. 1968. p. 8-9.

(13) POWELL, A. A., T. B. HAGLER, AND W. A. DOZIER, JR. 1979. Fruit Culture in Alabama. Ala. Coop. Ext. Ser. Cir. ANR-53. pp. 10-12.

(14) SMITH, O. CECIL AND MAURICE FERREE. 1969. Apples Enterprise Cost Analysis. Coop. Ext. Ser. Univ. of Ga. College of Agr. Misc. Pub. No. 82.

(15) STROTHER, G. R., W. GAZAWAY, A. A. POWELL, AND A. J. LATHAM. 1979. Alabama Spray Schedule for Commercial Apples. Ala. Coop. Ext. Ser. Cir. ANR 11.

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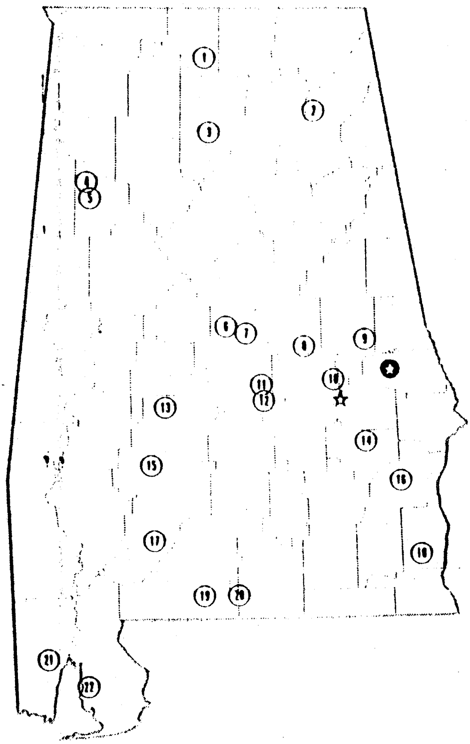

Research Unit Identification

⊛ Main Agricultural Experiment Station, Auburn.
☆ E. V. Smith Research Center, Shorter.

1. Tennessee Valley Substation, Belle Mina.
2. Sand Mountain Substation, Crossville.
3. North Alabama Horticulture Substation, Cullman.
4. Upper Coastal Plain Substation, Winfield.
5. Forestry Unit, Fayette County.
6. Foundation Seed Stocks Farm, Thorsby.
7. Chilton Area Horticulture Substation, Clanton.
8. Forestry Unit, Coosa County.
9. Piedmont Substation, Camp Hill.
10. Plant Breeding Unit, Tallassee.
11. Forestry Unit, Autauga County.
12. Prattville Experiment Field, Prattville.
13. Black Belt Substation, Marion Junction.
14. The Turnipseed-Ikenberry Place, Union Springs.
15. Lower Coastal Plain Substation, Camden.
16. Forestry Unit, Barbour County.
17. Monroeville Experiment Field, Monroeville.
18. Wiregrass Substation, Headland.
19. Brewton Experiment Field, Brewton.
20. Solon Dixon Forestry Education Center, Covington and Escambia counties.
21. Ornamental Horticulture Field Station, Spring Hill.
22. Gulf Coast Substation, Fairhope.