EFFECT OF FOUR PRUNING SEVERITIES ON THE APPLES OF LEBANON

by

Ghaleb A. Himadeh

A Thesis Submitted to the Graduate Faculty of
the School of Agriculture in Partial Fulfillment of
the Requirements for the Degree of

MASTER OF SCIENCE IN AGRICULTURE

Split Major: Horticulture - Agronomy

Minor: Entomology

Approved: Kenneth W. Hanson
In Charge of Major Work

G. W. Dagher

A. S. Jallouk

Ranji Khalily

G. W. Dagher
Chairman, Graduate Committee

American University of Beirut

1962

EFFECT OF FOUR PRUNING SEVERITIES ON THE APPLES OF LEBANON

by

Ghaleb A. Himadeh

A Thesis Submitted to the Graduate Faculty of
the School of Agriculture in Partial Fulfillment of
the Requirements for the Degree of

MASTER OF SCIENCE IN AGRICULTURE

Split Major: Horticulture - Agronomy

Minor: Entomology

Approved: Kenneth W. Hanson
In Charge of Major Work

W. H. Darrell

A. S. Jallouk

Ranji Khalaily

W. H. Darrell
Chairman, Graduate Committee

American University of Beirut

1962

Apple Pruning

HIMADEH

ACKNOWLEDGEMENTS

The author acknowledges with deep gratitude the advice, guidance and suggestions given by Dr. K.W. Hanson in directing the research for this experiment.

Special and sincerest thanks are due to Dr. J. Boustani of Deir El-Kamar and Dr. A. Hamadeh for allowing the running of this experiment to take place in their orchards.

The author wishes further to extend greatful acknowledgements to the following:

Dr. M. Hanania for her helpful suggestion concerning the method of statistical analysis.

Dr. W.W. Worzella, Dr. A.S. Talhouk and Dr. R. Khalidy for their critical study of this manuscript.

Mrs. K. Shomar for her patience in typing the final draft and to all those who helped to make this thesis possible.

ABSTRACT

Four different pruning methods, severe, moderate severe, light and nonpruning, was tested in 1960 for one year under the soil-climatic conditions of Deir El-Kamar and Safa in the Shouf district. The severe and moderate severe methods are the most commonly practiced in that area.

The purpose of the experiment was to test the effects of these pruning methods on linear growth, yield, fruit size and trunk girth.

The 188 tested trees of Golden Delicious and Starking Delicious were composed of four age groups: 12, 6, 5 and 3 years old.

Statistical analysis of the data by the use of the analysis of variance and the "t" test revealed that pruning is an essential operation. Though the four pruning severities affect significantly the linear growth, yield, fruit size and trunk girth, the moderate severe and severe methods in all analyses were not significantly different.

The results showed that the increase in yield and trunk circumference were inversely proportional to the increase in pruning severity and that light pruning offered the highest yield and increase in trunk circumference. Furthermore, the increase in linear growth and fruit size was directly proportional to the increase in pruning severity; and that severe and moderate severe pruning produced the largest terminal growth and larger sized fruit.

Accordingly, under the conditions of this experiment, light pruning proved to be the best since it gave adequate linear growth, highest commercial-sized fruit yield and the second larger-sized trees as reflected by the trunk girth data.

A continuation of this study is essential to verify the results on the best pruning severity under the Lebanese conditions.

TABLE OF CONTENTS

LIST OF TABLES

TABLE page

I N T R O D U C T I O N

The common apple, Malus sylvestris Mill. (Pyrus malus L., Malus Communis DC.), seems to be a collection of clones from hybridization between Malus sylvestris and other Malus species native to Western Asia in the Northern Himalaya Mountains (11). With the exception of the tropics and the two polar regions apples are present in every region, especially in the temperate and cold temperate zones where they are grown in great numbers. The apple ranks third (after grapes and bananas) in the total world fruit production with about 14.5 million metric tons annually (28).

Extensive cultivation of the apple in Lebanon began after 1945. The main varieties grown are Golden Delicious and Starking Delicious. Several other varieties are grown, mostly for home consumption. According to Kabbani (17) the overall area planted with apple trees is 73,750 dunums. This area contains 2,950,000 trees, of which 1,670,744 are of bearing age and produced about 60,000 metric tons in 1960. Moreover, the total capital investment in the apple industry was estimated by Kabbani to be 822 million L.L.

The growth and fruiting habit of apple trees are probably influenced as much by pruning as by any other orchard practice, and pruning has been proven to be one of the most important factors in successful orchard management (23). Although pruning is one of the oldest horticultural practices, and despite its importance and the importance of apples in

Lebanon, there is no branch of orchard management less understood or more unsuccessfully performed than the operation of pruning. While surveying the Lebanese apple regions, it was found that quite as many systems or methods of pruning prevail as there are fruit districts. All the different systems which are used have one common similarity, i.e., they generally fall under the severe pruning system. Since the beginning of the apple industry in Lebanon, the training tendency has been towards an open-center system; but recently, there has been a slight tendency to shift towards the modified leader system.

The many diversified pruning systems used are due to the lack of actual experimental trials under the soil- climatic conditions of Lebanon. Consequently, apple growers are unaware of the procedures that might enable them to determine the relative merits of the different methods and to choose the better practice. Moreover, the effect of pruning and training the branches of a tree may not be noticeable for several years. Unfortunately, many Lebanese growers who are now faced with this problem have never grown an apple tree to maturity. Consequently, the recommendations on this subject were not only from different sources but conflicting as well. These recommendations were based on observations and theoretical considerations that often have been stated in such indefinite terms that they were, and still are, misinterpreted.

Consequently, there is an urgent need for pruning studies which will lead to a method that will facilitate orchard operations and will increase yield, quality and size of fruit, and promote the vigor of a tree.

With this objective, this study was designed to evaluate four pruning severities and their effects on yield, annual linear growth, trunk girth and fruit size. We expect that this preliminary study will stimulate others to determine more accurately the proper pruning practices for apples in Lebanon.

REVIEW OF THE LITERATURE

Apple trees have been cultivated since the dawn of history. A considerable volume of literature dealing with the cultural practices employed during different periods has accumulated. However, a review of the early literature leads to the conclusion that the pruning of apple trees, for the purpose of influencing the amount and character of the fruit, was not consciously practiced.

The Romans confined their pruning practices to the removal of the dead wood as well as the irregular-crossing branches and only in a very few incidences did they head back the tree for the purpose of rejuvenation (23). The importance of the apple pruning practices in Europe was not recognized until comparatively recent times. The introduction of dwarfing stocks early in the seventeenth century started discussions about the subject in a definite form. Pruning, as now understood, was said to have its birth with the appearance of the book entitled, "La Maniere de Cultiver les Arbres Fruitiers" by Le Gendre in 1652. The dwarf trees at that time were considered as semiornamental adjuncts of a gentleman gardener. For this reason, the available European literature mostly discussed pruning as it concerned trees trained against walls. These trees were prized because of their ornamental value rather than the amount of fruit which they produced. Therefore, it is evident that the chief advantages claimed from the pruning methods employed were the appearance of the tree and its beauty rather than the quantity of the

fruit borne. Actually, the plan was to prune each tree with great care at frequent intervals to keep them small and to train them to the unnatural forms in vogue. Some writers recommended the removal of irregular-crossing shoots from each tree two or three times a week. Under this system of management the gardener often pruned for several hours a day during certain seasons. Meager in 1760 in England, as cited by Ricks and Gaston, reported in his book, "The English Gardener", that the gardeners of the period were well aware of the fact that the methods employed were not commercially advantageous to fruit growers.

La Quintinie in 1693 (22) in France, in his book "The Complete Gardener", wrote thirty nine chapters about pruning, mainly on dwarf trees. Pruning of "high-standards, or tall trees" received only a short paragraph which states "...I only desire, as I have said in the beginning of this treatise, that they (tall - standard) should be touched once or twice in the beginning, that is, in the 3 or 4 first years...". This statement, and the like by contemporaries, make it clear that the English and French gardeners were well aware of the limited application of their art of pruning.

It was not until the early part of the 19th Century that fruit growing in America began to be seriously practiced.

The American writers were classified into two fairly distinct classes (23). The first group believed that pruning is an indispensable orchard practice and recommended comparatively heavy pruning. The second group consisted of those who questioned the value of the conventional method at that time and recommended relatively little pruning. The first

group believed that heavy pruning results in:

(i) The improvement of the grade of the fruit.

(ii) Stimulation of production in the lower inner parts of the tree.

(iii) Keeping the tree "within bounds" so as to facilitate cultural practices, such as thinning, spraying and harvesting.

In this group, Manning, as cited by Ricks and Gaston (23), took the lead in 1884 in New England. He favored heavy pruning. His publications, and the fact that he was a systematic pomologist, greatly influenced the practices of fruit growers of his time. Barry in 1851 and Thomas in 1885, as reported by Ricks and Gaston , made it clear that they favored heavy pruning too.

Bailey (3) was probably more widely read than any other author. His book, "Principles of Fruit Growing", was extensively used as a textbook. His book on pruning which appeared in 1898 was the first important American work devoted entirely to this subject. His position is made clear by his statement, "...I am convinced that pruning, even when somewhat heroic, is not a devitalizing practice...".

With the beginning of the 1900's, the source of the horticultural information became the experiment station bulletins. The number of bulletins on this subject of pruning is considerable.

Allison in 1918 (2) adopted and intensified the ideas of the early American writers who favored severe pruning with the opening of the top of the tree. Allison's ideas got full support from Roberts who

in 1925 suggested the opening of the tops in a somewhat severe manner (24). His opinion is based on allowing light into the tree for the purpose of promoting fruit production in the lower and the central positions. Burkholder and McCown in 1929 (7) stated that the tops of mature trees should be kept open and not allowed to grow too high. To attain this objective they recommended a system which is more or less severe. Beach in 1934 (4) also suggested severe pruning methods. Men such as Manning, Bailey and Beach, were highly respected and their writings were followed closely. Not many dared to question their recommendations. Yet, in actuality a number of the early writers, and at least a few of the modern ones, who constituted the second group have questioned the ideas of the first group.

The second group has recommended more or less a light pruning system (23). This group had little influence prior to 1900, and very few papers were published. The first statements by this group were presented in the publications of Cox in 1817 and Kenrich in 1845. Both of those men preferred little or no pruning to the severe method that was commonly used. Warring, as cited by Ricks and Gaston, in 1851, was another of the early writers who recommended that bearing trees should be lightly pruned. However, he indicated that in Europe heavy pruning might have an advantage by exposing the inner parts of the tree to the sun. Obviously, where the sun is more intense such pruning would not be necessary. After 1900 this group was fortunate to have Downing among its defenders. The fact that he witnessed the birth of the modern pruning bulletins and his convincing publications made him unquestionably

one of the greatest horticulturists of his time. In a discussion of pruning, Downing wrote, "Take out all weak and crowding branches; those which are filling uselessly the interior of the tree where the leaves cannot be duly exposed to light and the sun".

Downing's recommendations opposed the first group who recommended the thinning out of the tops; a process that would expose the centre as well as the lower inner parts of the tree to the sun. It is notable that none of the writers cited have supported their statements by experimental evidences. Their statements were mere opinions; opinions which are based on observations, even if by able men, are sometimes proven erroneous. From the contrasting views so far expressed at least one of the two groups must be in error.

Many experiments have been conducted on pruning and, for the sake of the sequence of this dissertation, the reviewed results will be discussed under the following headings:

1. The effect of pruning on the size and vigor of the tree.
2. The effect of pruning on the yield of the tree.
3. The effect of pruning on the size of the fruit.
4. The effect of pruning on the trunk girth.

1. The Effect of Pruning on the Size and Vigor of the Tree

The studies reported by Gaucher in 1900 in Germany, as cited by Gardner (16), Bedford and Pickering in 1915 (5) in England, Alderman and Auchter in 1916 (1) in West Virginia and Gardner in 1916 in Oregon,

are considered to be the first experimental results reported in this field. Their conclusion was that severe pruning gives stockiness while light or no pruning gives large size trees (1, 5, 15, 16). Among the first pioneers to carry extensive experiments for a period of ten years were Bedford and Pickering. They planned their work to study carefully the effects of various severities of dormant season pruning on the apple. They reported that "moderate" and "hard pruning" reduced the weight of apple trees as compared to trees receiving very little or no pruning. Their data showed that unpruned and lightly pruned trees increased in size and weight more rapidly than the pruned trees, and the heavier the pruning the more pronounced is the retardation of growth. The explanation for the rapid increase in size of the unpruned trees was not that they produced more new shoots each year, but that they lost none or very few shoots by pruning. In contrast, heavy pruning gave fewer side shoots with less total length and weight than lighter pruning or nonpruning. Thus, the greater decrease was in the number of new shoots. Heavily pruned shoots, when individually compared to unpruned shoots, were longer and stronger.

Chandler in 1919 (9) working with young orchards concluded that any kind of pruning tends to be a dwarfing process and he said, "That it seems wise to permit the tree to assume its natural form". According to Tufts in 1925 (34) in California, the apple normally does not require heavy pruning. Approximately only 10 percent of its wood must be replaced each year because the fruit is borne largely on long-lived spurs. The apple requires somewhat less new wood growth than some other fruits.

The young bearing apple tree should ordinarily produce from ten to twenty inches of new growth each year, while with older trees six to ten inches is sufficient. However, if the wood growth shows a tendency to drop below the above-mentioned minimum amounts, heading back the laterals which are left after thinning out may be necessary to secure the proper vigor (34). This should not mean that excessive or severe heading back should be practiced. According to Tufts and Verner (37), such practice may encourage excessive vegetative growth and water sprout formation. Culliman and Backer in 1923 (13) in Purdue University studied pruning in young trees for the first four years of the life of the orchard trees. Their data showed that severe pruning reduced tremendously the size of the tree by reducing the leaf surface of the young tree and by removing a large number of active buds and growing points that would open into foliage. They further stated that not only the top has been reduced but also the root system has been correspondingly reduced. Moreover, they concluded that if the weight of one year's growth is taken as a measure of vigor, then pruning which is more or less severe is an invigorating process. However, the effect of pruning should be considered on the tree as a whole. For this reason Culliman and Baker have found that unpruned trees were heavier and that pruning, in general, has a dwarfing effect. Their studies also showed that the wood older than one year in the tops of the unpruned trees was heavier than the wood in severely headed back trees in the following proportion; 90% heavier in the second year, 60% heavier in the third year and 42% in the fourth year. Magness in 1941 (18) in Washington D.C., stressed that

in young trees no heading back of the branches or leader is necessary or desirable unless the tree is making exceptional growth. Also the young bearing apple trees should only receive a very limited amount of pruning. Talbert in 1947 (30) at Missouri suggested that although pruning seems to invigorate the trees, it actually has a dwarfing effect. His recommendations were that pruning in the first six years should be as light as possible, and in bearing trees pruning should be used to keep trees in profitable fruiting conditions. Light thinning-out at this stage should follow. Burkholder in 1948 (6) recommended heavy pruning in young apples as the result of the failure to prune annually. Heavy pruning is allowable only if the tree is three years old or below. After that, heavy pruning results in water sprout formation and retarded bearing. Thies in 1949 (31) stated that the objectives of pruning in young trees is to develop them into desirable shapes. All the corrective pruning should be made before the bearing age after which little pruning is required. He stressed the fact that pruning has a dwarfing effect, and that weak trees could be invigorated by the use of nitrogen fertilizers. Fairley, Childers and Christ in 1951 (14), Thomas in 1953 (32), agreed with Thies and recommended light annual pruning.

Preston in 1953 (21) in a seven-year study at East Malling concluded that the modified-leader pruning system gave more shoot growth and larger tree size than the open center system which is a more severe pruning method.

Roberts in 1954 (26) in a four-year experiment in Wisconsin recommended the "snipping method" which is a medium to a severe pruning

level for old orchards so as to put new life in them.

Tufts and Harris in 1955 (36) stressed that each year a certain amount of pruning is needed to insure a constant removal of fruit wood. To determine whether the pruning has been of the proper severity, estimating the total amount of new growth that the tree makes is the standard. If the annual growth of pruned branches has been longer than what it should be, then the previous pruning should have been severe. If the new growth has been inadequate, the previous pruning should be too light.

2. The Effect of Pruning on the Yield of the Tree

Gardner in 1916 (15) in Oregon, working with young apple trees, showed that the less pruning the higher the yield. He also added that with very severe pruning the yield decreases tremendously. Besides, he stated that varieties differ as to the amount of reduction when exposed to the same severity of pruning. The explanation is that with light pruning there is little reduction in the number of fruit spurs formed compared with the large reduction under severe pruning. It was found that varieties like Grimes, that are much inclined to develop spurs at an early stage, show a relatively greater check in fruit spur development than those like Rome and Gano which as young trees produce comparatively few spurs (16). In any case, pruning tends to reduce the number of spurs per tree.

The same results obtained by Gardner were achieved by Alderman in 1916 (1) in West Virginia, Bedford and Pickering in London in 1915 (5),

Tufts in 1919 and 1925 (33, 34) and Chandler (10). In their results they found that unpruned and lightly pruned trees yielded more than heavily pruned trees. Moreover, heavily pruned trees came into bearing more slowly.

Chandler continued even further while discussing the thinning out of the top to admit light. He stated that leaving the heads rather dense would reduce the percentage of well-coloured fruits; yet, because of the much larger yields, there apparently was considerably more well-coloured fruit than if greater thinning out had been done.

Marshall in 1928 (19) obtained several convincing experimental evidences on the effect of pruning as far as the income per acre is concerned. Working with mature apple trees he summarized his results as follows: pruned trees of mature age that were in a moderately vigorous to vigorous condition produced fewer apples, smaller yields and lower net returns per tree, or per acre, than unpruned ones. The differences were proportional to the severity of the pruning treatments. Marshall's work caused some observers to doubt the value of any pruning at all. After that, comparatively few bulletins about pruning appeared which were not influenced by Marshall's work.

This situation urged Ricks and Gaston in 1935 (23) of East Lansing, Michigan, to run a very important investigation which led to the classical thin-wood method of pruning for bearing trees. This method is considered as a light pruning level which results in better yields than moderate, severe or nonpruning methods. Talbert in 1947 (30) at Missouri concluded that old trees in a low state of vigor are generally made more profitable by light pruning. Pruning that reduces yield to improve grade of the fruits is unprofitable when there is a wide range.

between selling prices of grades A and B.

Burkholder in 1948 (6), at Indiana, Thomas in 1953 (32) and Preston in 1953 (21) in England compared various levels of light pruning which is similar to the thin-wood method described by Rick and Gaston. They obtained similar results, which were that light pruning gave the maximum yield, compared to medium, severe, and even nonpruning methods.

Data obtained by Alderman and Auchter in 1916 (1) with Arkansas and York Imperial apple trees, that had been bearing for a number of years but somewhat lacking in vigor, showed a steady increase in yields with each increase in the severity of the pruning. Similar results were reported for the Anjou pear. The increase in yield must have been due either to the formation of a larger number of fruit buds or to the better setting of the blossoms.

Gardner in 1952 (16) commenting on the results of Alderman on apples and pears stated that it was not to be expected that continued heavy pruning of the same trees would result in further increase in yields; nor, can pruning be generally recommended to secure benefits that can be obtained more readily by means of soil treatment.

3. The Effect of Pruning on the Size of the Fruits

Harting 1891, Burns 1891, as cited by Gardner (16), and Tufts in 1925 (34) concluded that heavy pruning results in larger-sized fruits when compared to nonpruning, moderate or light pruning.

Rick and Gaston in 1935 (23) at Michigan found that the size of an apple fruit tends to be directly proportional to the diameter of

the branch upon which it is born. Moreover, they got a decrease in inferior fruit yields by the thin wood pruning method and an increase in the average size of the fruit.

Talbert in 1947 (29) found that vigorous trees produce more apples of larger size when pruned than when not pruned. Roberts in 1952 (25) in Wisconsin showed that by thinning all weak-growing branches and spurs, and heading back half the last year's growth, the trees produced large leaves and consistently larger apples throughout the tree. Thomas in 1953 (32) in a comparative investigation showed that severe pruning gave the largest-sized apples compared with medium and light pruning levels.

Calhan in 1953 (8) describes the "Allen method" which is a type of severe pruning that led to larger and well coloured fruits. The explanation of most of the above-mentioned results is that the leaf area left was highly efficient in giving nutrients to the remaining fruits.

4. The Effect of Pruning on the Trunk Girth

Tufts in 1939 (35) in California showed that trunk development is correlated with the total development of a tree.

Alderman and Auchter in 1916 (1) in West Virginia showed that heavily pruned trees had an average increased trunk diameter of 1.61 inches, those moderately pruned had 1.69 inches and the lightly pruned 1.93 inches.

Culliman and Baker in 1923 (13) concluded that the greatest increase in trunk girth is achieved by unpruned trees compared to severely pruned ones.

Thomas in 1953 (32) compared the effect of three levels of pruning, severe, medium and light, on the trunk girth of Jonathan. He found that the three levels showed no significant differences.

Preston in 1953 (21) showed that the larger increase in trunk girth was obtained by the use of the lightest method of pruning in a comparative experiment.

MATERIALS AND METHOD

The experiment was conducted in the Fall of 1960 and early Winter of 1961 in the Shouf district.

Two orchards were selected in two locations to be a representative sample of the apple in that area.

The first orchard was in Deir El-Kamar (elevation 900 meters) owned by Dr. J. Boustani and the second in Al-Safa (950 meters above sea level) owned by Dr. A. Hamadeh. The two orchards are 40 kilometers south-east of Beirut.

Both orchards are located in a mountainous district and situated on slopy sites. They are fortified with a terracing system to control the hazard of winter eorsion. The soil is of the loamy clay type. The total number of trees and the distribution of varieties, according to the age of trees, in both orchards, with the number included in this study are shown in Table I.

This table shows that there are four age groups. Each group consists of the two varieties, Golden Delicious and Starking Delicious (hereafter referred to as Golden and Starking, respectively), which are the leading and most prevalent varieties in Lebanon.

The total number of Goldens in both orchards is 945 trees whereas the Starking number 546 trees. The total of the trees in both orchards is 1491 of which 188 were included in this experiment - 96 - Golden and 92 Starking. From each age group 48 trees were selected at

TABLE I

THE VARIETIES, AGE AND NUMBER OF TREES

LOCATED IN TWO ORCHARDS IN THE SHOUF DISTRICT

	Age of Trees	Variety	No. of Trees	Total Number	No. taken into exp.
Deir El-Kamar Orchard					
Group I	3 years	Golden	156		24*
				193	
	3 years	Starking	37		24*
Group 2	5 years	Golden	144		24*
				333	
	5 years	Starking	189		24*
Group 3	6 years	Golden	245		24*
				265	
	6 years	Starking			20**
Al-Safa Orchard					
Group 4	12 years	Golden	400		24*
				700	
	12 years	Starking	300		24*
Total: 4 Groups	4 age groups		2 Varieties	1491	188

*Six replications only.

**Five replications only.

random, 24 from each variety. From group 3 only 20 Starking trees were available, hence, this group has a smaller number of trees included than the other groups. The trees in the two orchards are trained to the modified leader system.

The experimental design used was a variation of the split-block design in which 4 levels of pruning severities were tested. Each variety in each age group, being planted in a confined area, was considered as a block in which the 4 pruning treatments were tested. Each treatment was replicated 6 times in each block except for Starking in group 3 where it was replicated 5 times because the total number of trees is 20. The 4 levels of pruning severities which are described in Table II are designated as:-

T1-Treatment I for severe pruning.

T2-Treatment II for moderate severe pruning.

T3-Treatment III for light pruning.

T4-Treatment IV for no pruning at all.

Treatments I and II are the dominant pruning practices in the Shouf district.

Before pruning, the following measurements were taken in November, 1960; (a) Trunk circumference measured one foot above the union, (b) the linear growth of the previous season's growth of the branches in each tree.

The pruning operations were made during late December, 1960 and early January of 1961.

TABLE II

DESCRIPTIVE TABLE OF PRUNING METHODS

Severe Pruning (T1)	Moderate Severe Pruning (T2)	Light Pruning (T3)
1) Head back 70% of last year's growth.	1) Head back 50% of last year's growth.	1) No heading back
2) Thin out: a. Shaded scaffolds & crossing branches. b. Weak angled branches. c.* All thin wood & any 4 year old branches from 3/8" & less (in thickness).	2) a. Mild Thinning out of crossing branches to correct wrong scaffold, spacing & save needed scaffold & branches. b. Thinning out weak angled branches. c. Thinning out any 4 year old wood having a thickness of 2/8" & less.	2)** Thinning out: a. Very weak angles, dead wood and suckers. b. Only thin out any 4 year old wood having a thickness less than 2/8".

*In case of Group I trees, the thin wood is the very thin unhealthy twigs.

**In case of Group IV trees, no branch thinning out is used in the light pruning method except where the branch has most of its sub-branches drooping down towards the ground or has very weak wood.

The cultural practices used were the conventional methods in that region, and they were constant for all treatments in both orchards. The soil manuring and fertilization rates were applied as described in Table III.

The time of application of these fertilizers was as follows:

(a) P and K were applied with animal manure in late November.

(b) N was applied in two applications: the first one in the first week of April in the form of $(NH_4)_2SO_4$, and the second application with the first irrigation in May in the form of NH_4NO_3.

The irrigation was practiced three times throughout the whole season. It should be noted that the irrigation is by turn and every person has the right to use the whole amount of water in the canal for a certain time. In our case, the quantity of water allowed to us per irrigation was always sufficient to flood the basins.

Spraying for the prevention and control of diseases and insects was practiced. The same chemicals were used in the same dosage in both orchards. During the period of the experiment no economical insect or disease injuries were observed.

Three cultivations for weed control were done as follows: The first cultivation was done during the dormant season, about the middle of March. The design, the reformation of the basins and irrigation systems were also done following this cultivation. The second and third cultivations were practiced before the first and second irrigation in mid May and at the beginning of July. In all the cultivation practices

TABLE III

THE CONVENTIONAL METHOD OF

FERTILIZER APPLICATION EXPRESSED IN KGS/TREE

Trees' age	Animal manure*	N/NH_4SO_4 & N/NH_4NO_3**	P/super-phosphate**	K(KCL)**	Total Wt. of fert.
3 years old	15 kgs.	1.5 kgs.	1.00 kgs.	0.50 kgs.	3 kgs.
5 years old	25 kgs.	2.5 kgs.	1.67 kgs.	0.83 kgs.	5 kgs.
6 years old	35 kgs.	3.0 kgs.	2.00 kgs.	1.00 kgs.	6 kgs.
12 years old	50 kgs.	6.0 kgs.	4.00 kgs.	2.00 kgs.	12 kgs.

*Goat manure was used on all of these trees through 1957 and since then Cow manure was used.

**Nitrogen was used as $(NH_4)_2SO_4$ and NH_4NO_3 21% (N).

**P used was as superphosphate 16% (P_2O_5).

**Potassium was used as (KCL) 50% (K_2O).

The Fertilization ratio used for N:P:K is 3:2:1.

no machine was used. Digging by hand-tools to a depth of 15-20 cms. was the only way. The second and third cultivations were confined only to the control of weeds within the basins.

In September 1961, the yield data per tree was computed. The number of fruits per tree was distributed into four classifications as follows: $< 2"$, $2\text{-}2\frac{1}{2}"$, $2\frac{1}{2}"\text{-}3"$, $> 3"$.

The seasonal trunk girth and linear growth of branches were measured in early October for the 1961 season. All these measurements were made by the same tape used for the first ones. The objective of these measurements was to give results on the comparative effects of the tested pruning severities on the (a) Trunk girth, (b) Linear growth of branches and limbs and (c) Production as expressed by total yield and fruit size.

The results were analyzed by the analysis of variance. An adjustment for the missing replicate in the 6-year Starking block was made according to Cochran and Cox (12). The design of the analysis was set to sacrifice precision in the comparison of the effect of different ages and varieties in order to gain sensitiveness in the treatment analysis. This is quite allowable (12, 20) since the purpose of this study is to test for the treatment effects and not differences between varieties nor the effect of ages which is universally known. Accordingly, any small differences in treatments can be easily detected significantly.

A contingency table was made to test whether there is a dependence between treatments used and the size of apple produced. Then a "t" test was made for testing significance between the treatments affecting fruit size.

RESULTS AND DISCUSSION

1. The Effect of Pruning on Linear Growth

The data in Table IV, which represents all the informations on linear growth, was critically analyzed and studied.

It is clearly shown in Table V that under all treatments linear growth is inversely proportional to age. Only the three years old trees were found to show a lesser terminal growth compared to the five and six years old trees. The explanation for this deviation is that the trees in the three years old block, especially Starking, were the poorest among all the other age groups. The reason for the weak trees, may be traced back either, to the previous poor management, insufficient irrigation the last 2 years prior to the study and to soil heterogeneity, or to both. Since there is no significance in replications (Table VII), which expresses no soil heterogeneity, then the first two reasons may stand for the probable explanation. Moreover, data in Table V shows that although the linear growth appears to decrease progressively with age it is not statistically significant.

Previously, it was mentioned that the normal required linear growth for bearing trees is 6" - 10" while for non-bearing trees it is 10" - 20" (34). However, it was shown in this study that bearing trees had more linear growth than the normal whereas the non-bearing trees had just about a normal amount. This may be due to the fact that the older bearing trees had more favorable conditions. Furthermore, the

TABLE IV

THE EFFECT OF 4 PRUNING SEVERITIES ON THE LIEAR GROWTH IN CM.

OF 4 AGES OF 2 VARIETIES OF APLE TREES

Age	Varieties Replicates	Treatment I R1 R2 R3 R4 R5 R6 ΣTI	Treatment II R1 R2 R3 R4 R5 R6 ΣTII	Treatment III R1 R2 R3 4 R5 R6 ΣTIII	Treatment IV R1 R2 R3 R4 R5 R6 ΣTIV	Σ Variety	Age Total	M. Age
3 years	Golden	41 24 61 58 56 31 271	25 25 37 65 43 52 247	46 39 37 5 43 52 282	15 29 22 22 31 31 150	950	1739	36.2
	Starking	58 22 26 48 12 35 201	41 95 12 33 54 22 257	43 23 22 6 36 18 178	29 28 19 18 37 22 153	789		
5 years	Golden	62 58 76 64 57 61 378	49 47 48 48 54 55 301	38 29 28 8 37 53 243	31 33 28 45 35 57 229	1151	2272	47.3
	Starking	64 65 41 54 28 56 308	47 40 40 47 39 53 266	41 44 42 42 40 57 266	41 67 38 44 36 55 281	1121		
6 years	Golden	44 79 74 25 40 37 299	57 87 64 71 33 37 349	33 37 34 45 30 73 252	44 22 36 58 28 39 227	1127	2059	42.8
	Starking	37 44 41 41 37 41 241	46 38 40 53 34 40 251	29 48 40 43 42 40 242	35 30 62 24 16 31 198	932		
12 years	Golden	53 48 39 44 31 44 259	47 36 30 40 19 33 205	26 22 22 20 18 22 130	23 18 18 23 17 14 113	707	1589	33.1
	Starking	40 52 45 47 65 66 315	38 38 40 74 46 37 273	31 32 35 22 21 25 166	22 18 20 20 29 19 128	882		
Treatment total		2272	2149	1759	1479			
Treatment mean		47.33	44.77	36.65	30.81			

TABLE V*

THE EFFECT OF AGES AND VARIETIES

ON LINEAR GROWTH IN CMS. OF APPLE TREES

Variety	Age 3 years	5 years	6 years	12 years	Variety Total	Variety Mean
Golden	950	1151	1127	707	3935	41.0
Starking	789	1121	932	882	3724	38.7
Age total	1739	2272	2059	1589	7659	
Mean of ages	36.2	47.8	42.8	33.1		

Observed F:

Ages - N.S

Varieties - N.S

*Data measured in cms.

analyzed data showed no significant differences in linear growth between the two varieties.

In the present study, as shown in Table VI, the annual shoot growth was affected greatly by the tested pruning treatments. The differences in linear growth between the tested treatments were statistically significant. The terminal growth increased gradually with increased pruning severity in both varieties. The largest terminal growth was attained by treatments I and II which were severe and moderate severe, respectively. They are not significantly different, though treatment I gave a longer terminal growth. Treatment III, a light pruning method, ranked third in the progressive scale. It gave a lesser terminal growth than treatments I and II but a longer terminal growth than treatment IV, which is a nonpruning method.

These results showed a pattern of gradual increase of terminal growth with increasing pruning severity. Moreover, all the treatments gave a terminal growth above the minimum required.

There were no significant differences in linear growth between severe and moderate severe pruning. This insignificance may be explained by the fact that the severity of pruning between treatments III and II is more than that between treatments I and II, comparatively, as has been shown in Table II . Consequently, this small difference between treatments I and II may not account for significance in a one year test. This same tendency holds true in later analysis on the effect of pruning on yield and trunk girth wherein no significant differences appear between severe and moderate severe prunings.

TABLE VI

THE EFFECT OF FOUR PRUNING TREATMENTS AND

AGES ON THE LINEAR GROWTH IN CMS. OF

GOLDEN DELICIOUS & STARKING DELICIOUS

Ages	Treatments	T1	T2	T3	T4
3 years		472	304	460	303
5 years		686	567	509	510
6 years		540	600	494	425
12 years		574	478	296	241
Treatment total		2272	2149	1759	1479
Mean of treatments		47.33	44.77	36.65	30.81

L.S.D. between means at the 5% level

Treatment = 4.39

Observed F:

Treatment = 22.688^{**}

Ages = N.S

Treatment No:	1	2	3	4
Mean linear growth in cms.*	47.33	44.77	36.65	30.81

* _____ denotes treatment means that did not differ significantly at the 5% level.

** denotes treatments are significant at the 1% level.

The results attained in this study are in full agreement with the previous work of Alderman and Auchter (1), Chandler (10) and others (27, 33, 34).

In this study the interactions between age x variety and (age x variety x treatment) as shown in Table VII were found to be significant. This is explained by the profound effect of the significantly different treatments on both interactions. In spite of the significant differences between treatments and their profound effects on interactions yet the interaction between variety and treatment was not significant.

2. The Effect of Pruning on Yield

The yield data is presented in Table VIII. It is obvious and normal to find that the yield in both varieties is in the following descending order; the 12-years, 6-years and 5-years group.

What appears strange is that there is no significant differences between the means of the three age groups in spite of the great differences between them. This is quite reasonable when we know that the degrees of freedom of the error which determines the F value of the age is so low. Consequently, this will not give significance unless the mean differences were exceptionally high (20).

As previously mentioned, this design of the analysis was purposely set to sacrifice precision in the comparison of mean ages in order to gain more sensitiveness and precision in the treatment analysis since the effect of ages on yield is universally known.

Furthermore, Table IX shows no significant differences in yield between the two varieties.

TABLE VII

ANALYSIS OF VARIANCE FOR LINEAR GROWTH

IN GOLDEN AND STARKING DELICIOUS

Sources	D.F	M.S	F.
Age (A)	3	1982.1	3.38
Variety (V)	1	231.9	10.39
Error (a)	3	585.7	
Treatment (T)	3	2754.4	22.69**
Age x Treatment	9	320.4	2.64**
Variety x Treatment	3	116.4	0.96
Age x Variety x Treatment	9	547.3	4.51**
Replication	39	190.9	1.57
Error (b)	117	121.4	

** denotes F value significant at the 1% level.

TABLE VIII

THE EFFECT OF 4 PRUNING SEVERITIES ON THE YIELD OF
3 AGES OF 2 VARIETIES OF APPLE TREES EXPRESSED IN KGS./TREE

Age	Varieties	Replication	Treatment I R1	R2	R3	R4	R5	R6	ΣTI	Treatment II R1	R2	R3	R4	R5	R6	ΣTII	Treatment III R1	R2	R3	R4	R5	R6	ΣTIII	Treatment IV R1	R2	R3	R4	R5	R6	ΣTIV	Σ Variety	Age Total	Age Mea
3 yrs.	Golden																															
	Starking																															
5 yrs.	Golden		13	8	4	8	11	12	56	9	14	15	16	17	16	87	29	51	29	31	16	34	184	24	27	24	35	19	28	157	484	747	15.56
	Starking		3	5	1	2	3	8	22	7	7	11	6	8	7	46	6	25	24	10	23	35	123	16	12	14	2	13	15	72	263		
6 yrs.	Golden		7	15	16	4	4	10	56	14	15	12	12	16	11	80	15	17	24	26	50	35	167	7	20	15	16	17	28	103	406	780	16.25
	Starking		11	14	9	6	3	9	52	9	11	14	12	12	12	70	22	25	29	27	38	28	169	15	15	14	13	12	14	83	374		
12 yrs.	Golden		161	130	48	101	103	235	778	47	67	58	78	175	213	638	217	217	146	207	174	228	1189	179	300	198	98	252	231	1258	3863	6314	131.54
	Starking		63	69	106	70	100	70	478	114	75	152	75	71	51	538	156	164	125	157	108	127	837	44	104	134	180	62	74	2271	2451		
Treatment total									1442							1459							2669							2271			
Treatment mean									40.05							40.53							74.14							63.08			

TABLE IX

THE EFFECT OF AGES AND VARIETIES

ON THE YIELD IN KGS. OF APPLE TREES

Variety Age	5 years	6 years	12 years	Variety total	Variety Mean
Golden	484	406	3863	4753	66.0
Starking	263	374	2451	3088	42.8
Age total	747	780	6314		
Age mean	15.56	16.25	131.54		

Observed F:

Ages - N.S

Varieties - N.S

The effect of pruning severity is shown in Table X. The results prove that as we increase the level of severity the yield decreases in all the ages and in both varieties. Moreover, the analysis confirmed that yield was affected noticeably by the tested pruning treatments, and that light pruning gave the highest yield followed by nonpruning, moderate and severe pruning treatment.

Accordingly, when comparing pruning with nonpruning, some light pruning is essential. On the other hand, nonpruning was found to be far better than severe and moderate severe pruning. It was interesting to note that in yield, as in linear growth, there was no significant differences between moderate severe and severe pruning. The same previous explanation also holds here.

A portion of the yield differences obtained is due to the fact that as we increase the pruning severity, we also reduce the number of fruit buds proportionally. Consequently, some yield reduction should be expected. The same results were attained by previous workers (10, 19, 27). They showed that yield decreased proportionally as pruning became more severe. Other workers showed that light pruning gave the highest yield when compared with nonpruning, moderate and severe levels (6, 23, 30, 32). All these results are in accordance with our findings.

Table XI shows that all the interactions in the analysis were found to be significant. Again, this may be explained by the profound effects of the significantly different pruning treatments under all interactions. Moreover, in this analysis the replications were found to differ significantly. This is explained in part to the fluctuation

TABLE X

THE EFFECT OF FOUR PRUNING TREATMENTS AND AGES

ON THE YIELD IN KGS. OF GOLDEN & STARKING DELICIOUS

Ages	Treatments yield in kgs.	T1	T2	T3	T4
5 years		78	133	307	229
6 years		108	150	336	186
12 years		1256	1176	2026	1856
Treatment total		1442	1459	2669	2271
Mean of treatment		40.05	40.53	74.14	63.08

L.S.D. between means at the 5% level.

treatment = 8.124

Observed F:

Treatments = 33.3^{**}

Ages = N.S

Treatment No.	3	4	2	1
Mean yield in Kgs.	74.14	63.08	40.53*	40.05

**denotes treatments are significant at the 1% level.

*_____ denotes treatment means that did not differ significantly at the 5% level.

TABLE XI

ANALYSIS OF VARIANCE FOR YIELD

IN GOLDEN AND STARKING DELICIOUS

Sources	D.F	M.S	F.
Age (A)	2	213950.5	18.4
Variety (V)	1	19251.6	1.6
Error (a) (Va)	2	11661.8	
Treatment (T)	3	10358.7	33.3**
Age x Treatment (AxT	6	3206.7	10.3**
Variety x Treatment (VxT)	3	1834.6	5.9**
Age x Variety x Treatment (AVT)	6	5319.8	17.1**
Replications (R)	29	1668.9	5.4**
Error (b)	87	310.7	

** denotes F value significant at 1% level.

in yields of the young bearing trees which were fruiting for the first time, and secondly to some soil heterogeneity factors between the blocks.

3. The Effect of Pruning on the Size of the Fruits

The data on fruit size, as shown in Table XII, were grouped into four classifications according to the Lebanese fruit board rules of grading. The contingency table analysis was used in analysing this data. The results showed that the fruit size classification are strongly dependent on the treatments used; i.e., the kind of treatment has an effect on the size of apples produced.

Moreover, the data showed that the fruit size increases when increased pruning severity is applied.

The "t" test, as shown in Table XIII, was applied for detecting significance among the treatments. Accordingly, the treatments were found to be significantly different. The means of the treatments were arranged in a descending order according to sizes. Severe pruning gave the largest fruit size, followed by moderate, light and nonpruning. Consequently, in this study, fruit size was found to increase with increased pruning. This finding is similar to that of other workers (1, 19, 25, 30). It is of importance to note that in Lebanon apple growers can sell all apples above 2 inches for the same price. Those below 2 inches are sold for lower prices, especially for processing. The described classifications in this study must be adhered to by the exporters.

TABLE XII

CONTINGENCY TABLE SHOWING DISTRIBUTION OF FRUITS

IN EACH TREATMENT ACCORDING TO SIZE CLASSIFICATION IN INCHES

Treatments / Size classification	<2"	2"-2½"	2½"-3"	>3"	Total of treatments	Average apple size of treatment	Total $\frac{(O-E)^2}{E}$ of treatments
T1	0	4133	3957	1118	9208	2.586	5764
T2	125	4255	3990	561	8931	2.529	3381
T3	91	14625	3040	27	17810	2.334	1057
T4	1043	16519	160	0	17722	2.225	5791

$$\Sigma \frac{(O-E)^2}{E} = x^2$$

$$x^2 = 15993^*$$

*denotes that size classification is highly dependent on the type of treatment.

TABLE XIII

"t" TEST ANALYSIS FOR TREATMENT MEANS

OF FRUIT SIZES*

Mean comparison		T Value
T1 and T2	$\frac{m_1 - m_2}{S} \sqrt{\frac{n_1 n_2}{n_1+n_2}}$	12.074**
T2 and T3	$\frac{m_2 - m_3}{S} \sqrt{\frac{n_2 n_3}{n_2+n_3}}$	61.90**
T3 and T4	$\frac{m_3 - m_4}{S} \sqrt{\frac{n_3 n_4}{n_3+n_4}}$	62.26**

Mean treatment No: arranged in descending orders:-

	1	2	3	4
Mean sizes	2.586	2.529	2.334	2.225

*size in inches.

**T value denotes that treatment means are highly significantly different.

Taking the present situation as such, the trees which were pruned lightly produced the highest commercial yield followed by nonpruning. Moderate and severe pruning levels reduced the yields significantly. These findings are similar to those of other workers (10, 23).

4. The Effect of Pruning on Trunk Girth

Table XIV shows the data analyzed in this study which represent the increase in trunk circumference of the trees during the 1961 growing season.

Table XV shows that there is a decrease in circumference gain as the trees get older. This decrease is not regular through all the ages since in the age six, the increase is the highest. This is explained by the fact that the 6-year Golden trees are the best among all the other group ages in Deir El-Kamar orchard. Being near the water source this age group received sufficient irrigation whereas in previous years there was hardly adequate water quantity to irrigate more than one block. Although there was a descending order in trunk circumference gain with age it was not significant. As previously mentioned, the three year old trees were apparently the poorest among all the other age groups. This is also reflected in the results of the linear growth (Table IV). A partial explanation for these results may be that the three year block was situated the furthest from the water supply. Moreover, this block was the furthest down the slope. Consequently, the younger trees had comparatively unfavorable growth conditions.

TABLE XIV

THE EFFECT OF FOUR PRUNING SEVERITIES ON

THE TRUNK GIRTH IN CMS. OF 4 AGES OF 2 VARIETIES OF APPLE TREES

Age	Varieties	Replication	Treatment I R1	R2	R3	R4	R5	R6	ΣT1	Treatment II R1	R2	R3	R4	R5	R6	ΣTII	Treatment III R1	R2	R3	R4	R5	R6	ΣIII	Treatment IV R1	R2	R3	R4	R5	R6	ΣIV	ΣVariety	Age Total	Age Mean
3 years	Golden		3.0	1.0	2.0	2.0	2.0	2.0	12.0	2.0	2.0	2.0	3.0	2.0	3.0	14.0	2.0	2.0	2.0	3.0	2.0	2.0	13.0	3.0	2.0	3.0	2.0	1.5	3.0	14.5	53.5		
	Starking		2.0	2.0	1.0	2.0	0.5	1.0	8.5	1.0	1.0	1.5	0.5	2.0	2.5	8.5	2.0	2.5	1.5	1.0	1.0	1.5	9.5	2.5	3.5	2.0	1.0	1.0	1.0	11.0	37.5	91.0	1.83
5 years	Golden		1.0	2.0	2.0	1.0	2.0	2.0	10.0	2.0	1.5	2.0	1.5	2.0	1.0	10.0	2.0	1.5	2.0	2.0	1.0	2.0	10.5	1.5	2.0	3.5	1.0	3.0	2.0	13.0	43.5		
	Starking		2.0	1.0	1.0	1.0	1.0	2.0	8.0	1.0	1.0	1.0	1.0	1.0	2.0	7.0	1.0	2.0	3.0	4.0	0.5	1.0	11.5	2.0	2.0	2.5	2.0	2.0	2.5	13.0	39.5	83.0	1.73
6 years	Golden		1.0	2.0	2.0	2.0	2.0	2.0	11.0	3.0	1.0	1.0	3.0	1.0	2.0	11.0	3.0	3.5	3.0	2.0	1.0	1.0	13.5	4.0	3.0	5.0	2.0	2.0	2.0	18.0	53.5		
	Starking		2.0	0.5	1.0	2.0	1.0	1.3	7.8	1.0	1.5	1.0	1.0	1.0	1.1	6.6	1.0	3.0	1.0	3.0	1.0	1.8	10.8	2.0	2.0	3.0	2.0	2.0	2.2	13.2	38.4	91.9	1.91
12 years	Golden		2.0	1.0	1.0	1.0	1.0	1.0	7.0	2.5	1.0	1.5	1.5	2.0	1.0	9.5	2.0	1.0	2.0	2.0	1.0	2.5	10.5	2.0	1.0	2.0	2.0	3.0	3.5	13.5	40.5		
	Starking		1.0	2.0	1.5	1.0	0.5	1.0	7.0	1.0	2.5	1.5	1.0	0.5	1.0	7.5	1.5	1.5	2.0	1.5	1.0	1.0	8.5	3.0	2.5	2.5	1.0	1.0	3.0	13.0	36.0	76.5	1.59
Treatment total									71.30							74.10							87.80							109.20			
Treatment mean									1.49							1.54							1.83							2.28			

TABLE XV

THE EFFECT OF AGES AND VARIETIES

ON TRUNK GIRTH OF APPLE TREES EXPRESSED IN CMS.

Variety Age	3 years	5 years	6 years	12 years	Variety total	Variety mean
Golden	53.5	43.5	53.5	40.5	191.0	1.97
Starking	37.5	39.5	38.4	36.0	151.4	1.58
Age total	91.0	83.0	91.9	76.5		
Age mean	1.89	1.73	1.91	1.59		

Observed F:

Ages - N.S

Varieties - N.S

The varieties were found not to differ significantly in the increase of the trunk circumference.

Table XVI shows that the differences between the treatments were highly significant. The order of increase in trunk circumference is as follows: The highest gain was affected by nonpruning followed by light pruning whereas moderate and severe pruning gave the least increase. The same explanations which were presented earlier will hold true for this insignificance between moderate severe and severe pruning treatments. From the results obtained, it is apparent that there was less increase in trunk circumference with each increase in pruning severity. These findings were in accordance with results of previous workers.

According to Tufts (34), the trunk girth may be taken as a fairly accurate index of size.

Thus, we can use the measured data and the analyzed results to indicate the effect of pruning on the size. Accordingly, nonpruned trees are larger in size than pruned ones. Light pruning gave a larger-sized trees than either moderate or severe pruning. This is perhaps because nonpruned and lightly pruned trees have more terminals. These findings prove, as previously mentioned, that pruning in general is a dwarfing process (10, 30, 33).

Table XVII shows that, though the treatments were significantly different, the analyses of the interactions were not statistically significant. Moreover, the replications were found significantly different.

TABLE XVI

THE EFFECT OF FOUR PRUNING TREATMENTS ON THE

TRUNK GIRTH IN CMS. OF GOLDEN DELICIOUS

AND STARKING DELICIOUS

Ages Treatments	T1	T2	T3	T4
3 years	20.5	22.5	22.5	22.5
5 years	18.0	17.0	22.0	26.0
6 years	18.8	17.6	24.3	31.2
12 years	14.0	17.0	19.0	26.5
Treatment total	71.3	74.1	87.8	109.2
Treatment mean	1.49	1.54	1.83	2.28

L.S.D. between means at the 5% level.

Treatment = 0.07

Observed F:

Treatment = 17.306**

Ages = N.S

Treatment No:	4	3	2	1
Mean increase in trunk circumference in cms.	2.28	1.83	1.54*	1.49

** denotes treatments are significant at the 1% level.

* denotes treatment means that did not differ significantly at the 5% level.

TABLE XVII

ANALYSIS OF VARIANCE FOR TRUNK GIRTH

IN GOLDEN DELICIOUS AND STARKING DELICIOUS

Sources	D.F	M.S	F.
Ages (A)	3	1.1	1.22
Varieties (V)	1	8.2	9.11
Error (a), (VA)	3	0.9	
Treatment (T)	3	6.23	17.31**
Age x Treatment (AxT)	9	0.38	1.06
Variety x Treatment (VxT)	3	0.23	0.64
Age x Variety x Treatment (AVT)	9	0.56	1.56
Replication	39	0.65	1.81*
Error (b)	117	0.36	

**denotes F value significant at the 1% level.

*denotes F value significant at the 5% level.

TABLE XVII

ANALYSIS OF VARIANCE FOR TRUNK GIRTH

IN GOLDEN DELICIOUS AND STARKING DELICIOUS

Sources	D.F	M.S	F.
Ages (A)	3	1.1	1.22
Varieties (V)	1	8.2	9.11
Error (a), (VA)	3	0.9	
Treatment (T)	3	6.23	17.31**
Age x Treatment (AxT)	9	0.38	1.06
Variety x Treatment (VxT)	3	0.23	0.64
Age x Variety x Treatment (AVT)	9	0.56	1.56
Replication	39	0.65	1.81*
Error (b)	117	0.36	

**denotes F value significant at the 1% level.

*denotes F value significant at the 5% level.

This may be due to location, soil heterogeneity or any irrigation and management differences prior to the running of this experiment.

SUMMARY AND CONCLUSION

The competition from other areas and the lower margin of profits of the Lebanese apples makes higher yields and more economical production imperative. Consequently, the consideration of pruning practices, not previously studied, is essential.

Four pruning severities were tested in 1960 for a one year trial under the soil-climatic conditions of Deir El-Kamar and Safa in the Shouf district. The tested treatments were: severe, moderate severe, light and nonpruning methods. The severe and moderate severe pruning methods are the most commonly practiced in that area.

The purpose of the study reported in this thesis was to evaluate the effects of these four different pruning severities on linear growth, yield, fruit size and trunk girth of Golden Delicious and Starking Delicious apples.

The results show that the age of the trees is inversely proportional to the linear growth and directly proportional to yield and to trunk girth. However, statistical analysis of the data shows that these relationships are not statistically significant. Also, the differences between the varieties were not statistically significant.

The linear growth was significantly affected by the four pruning severities. All the terminal growth in all the treatments was above the minimum required.

A pattern of gradual increase of linear growth with increasing pruning severity was observed in both varieties. The severe and moderate severe methods, which are not statistically different, gave the longest terminal growth. Moreover, the interactions between age x treatment and age x variety x treatment are shown to be significant while variety x treatment interaction was not.

In yield the effect of pruning treatments prove that as we increase the level of severity the yield decreases in all the ages and in the two varieties. The light pruning treatment outyielded all the others. Nonpruning ranked the second whereas moderate severe and severe prunings gave the least yield and both were not significantly different. Moreover, the interactions in yield were significant.

The fruit size was found to be strongly dependent on the pruning treatments used. The increase in size was found to be directly proportional with increased severity. Severe pruning gave the largest fruit size followed by moderate, light and nonpruning.

The increase in the trunk circumference was found to be inversely proportional to the pruning severity. The treatments tested proved to be significantly different. Nonpruning gave the highest increase in trunk circumference followed by light pruning whereas moderate severe and severe pruning gave the least and were found insignificant.

From the results obtained in this study we may conclude that a light pruning treatment is essential for maximum apple production in Lebanon.

Furthermore, it was found that under the conditions of this experiment the conventional methods of pruning drastically reduced the yield of high quality apples. Light pruning gave adequate terminal growth, highest commercial-sized fruit yield and the second larger-sized trees as reflected from the trunk girth results.

It is worth while to continue this study for other seasons so that a more valid conclusion would be attained indicating the best pruning severity for apples under the Lebanese conditions.

LITERATURE CITED

1. Alderman, W.H. and E.C. Auchter. 1916. The apple as affected by varying degrees of dormant and seasonal pruning. W. Va. Agr. Exp. Sta. Bul. 158.

2. Allison, J.H. 1918. Hints on fruit tree pruning. Ia. Agr. Exp. Sta. Bul. 59.

3. Bailey, L.H. 1898. The pruning book. Macmillan Co., New York. pp.196.

4. Beach, F.H. 1934. Pruning fruit trees. Ohio Agr. Exp. StaM Ext. Bul. 145 (5th ed.).

5. Bedford, H.A.R. and S.U. Pickering. 1915. Results of pruning experiments at Wobern Experiment Farm. Wobern Exp. Farm Rep. No.15.

6. Burkholder, G.L. 1948. Pruning practices for Indiana apple orchards. Purdue Univ. Agr. Ext. Bul. 35L.

7. _____ and M. McCown. 1929. Pruning suggestions for Indiana apple orchards. Purdue Univ. Agr. Ext. Bul. 160.

8. Calhan, C.L. 1953. Pruning mature trees for easy picking. Amer. Fruit Grow. 73:8. Dec.

9. Chandler, W.H. 1919. Some results as to the response of fruit trees to pruning. Proc. Amer. Soc. Hort. Sci. 16:88-101.

10. _____ 1925. Results of experiments in pruning fruit trees. Cornell Agr. Exp. Sta. Bul. 415.

11. _____ 1951. Deciduous orchards. (2nd ed.) Lea and Febiger Co. Philadelphia. pp.249.

12. Cochran, W.G. and G.M. Cox. 1960. Experimental design. John Wiley and Sons, Inc. New York. pp.80.

13. Culliman, E.P. and C.E. Baker. 1923. Pruning young trees. Purdue Univ. Agr. Exp. Sta. Bul. 274.

14. Farley, A.J., N.F. Childers and E.G. Christ. 1951. Pruning bearing apple trees. N.J. Agr. Exp. Sta. Ext. Bul. 258.

15. Gardner, V.R. 1916. Pruning investigations. Oreg. Agr. Exp. Sta. Bul. 139.

16. _____ F.C. Bradford and H.D. Hooker. 1952. Fundamentsls of fruit production (3rd ed.). McGraw-Hill Co. Inc. New York. pp.555-565.

17. Kabbani, S. 1961. Production and marketing of apples in Lebanon. (A thesis submitted in partial fulfilment for the degree of Master of Arts in The Economic Department of the American University of Beirut).

18. Magness, J.R. 1941. Pruning hardy fruit plants. U.S.D.A. Farmers' Bul. 1870.

19. Marshall, R.E. 1928. Profit and loss in pruning mature apple trees. Mich. Agr. Exp. Sta. Spec. Bul. 169.

20. Pause, V.G. and P.V. Sukhatme. 1954. Statistical methods for agricultural workers. Indian Council of Agr. Res. New Delhi.

21. Preston, A.P. 1953. Apple pruning trials. (A progress report). East Mal. Res. Sta. Ann. Rep. pp.105.

22. Quintinie, L.A. 1693. The complete gardener Vol.11. Part IV. (trans. by John Evelyn) Macmillan and Co. London.

23. Ricks, G.L. and H.P. Gaston. 1935. The "thin wood" method of pruning bearing apple trees. Mich. Agr. Exp. Sta. Spec. Bul. 265.

24. Robert, R.H. 1925. Prune the bearing apple tree. Wis. Agr. Exp. Sta. Bul. 318.

25. _____ 1952. Pruning Golden Delicious to secure good size. Proc. Amer. Soc. Hort. Sci. 59:184-186.

26. _____ 1954. How to prune for eternal youth. Amer. Fruit Grow. 74:11. Dec.

27. Shaw, J.K. 1935. Pruning bearing apple trees. Mass. Agr. Exp. Sta. Bul. 320.

28. Simmonds, N.W. 1959. Bananas. Longman, Green & Co. LTD. London.

29. Snyder, J.C. 1957. Training young apple trees. Wash. Sta. Col. Ext. Bul. 522.

30. Talbert, T.Z. 1947. Pruning suggestions for apple and pear trees. Miss. Agr. Exp. Sta. Cir. 315.

31. Thies, W.H. 1949. Pruning deciduous fruit trees. Mass. Univ. Ext. Ser. Spec. Cir. 158.

32. Thomas, L.A. 1953. A pruning and rootstock trial with apple trees. Jour. Hort. Sci. 28:125-30.

33. Tufts, W.P. 1919. Pruning young deciduous fruit trees. Cal. Agr. Exp. Sta. Bul. 313.

34. _____ 1925. Pruning bearing deciduous fruit trees. Cal. Agr. Exp. Sta. Bul. 386.

35. _____ 1939. Pruning deciduous fruit trees. Cal. Agr. Ext. Ser. Cir. 112.

36. _____ and R.W. Harris. 1955. Pruning deciduous fruit trees. Cal. Agr. Exp. Sta. Ext. Ser. Cir. 444.

37. Verner, L. 1955. New method of training deciduous apple trees. Amer. Fruit Grow. 75:12.Mar.