DISTRIBUTION OF APPLE TREE ROOTS AS INFLUENCED BY SOIL CHARACTERISTICS

by

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INTRODUCTION

The purpose of this investigation is to study the root growth of apple trees as influenced by soil characteristics.

REVIEW OF LITERATURE

In reviewing horticultural literature it is somewhat surprising to find great differences of opinion as to the root growth of fruit trees.

Partridge and Veatch (22) state that the extent and character of the root system are influenced by variation in texture, structure, chemical nature, thickness and water content of the separate layers of the soil.

According to Toumey (29) the root habit in American trees is modified by environmental conditions, more particularly soil moisture. He points out that variarion in depth and rapidity of juvenile root penetration and in their lateral expansion is found in the different species depending primarily on the available soil moisture characteristic of the superficial layers of the soil and the moisture requirement of the species. This is also shown by Jean and Weaver (11), Weaver, Jean and Crist (33) and Weaver (31), (32) and his coworkers to be the case.

Oskamp and Batjer (20) found that trees in the better drained soils of western New York had a deeper root system than those in poorly drained soils. Oskamp (21) also believed that sufficient moisture content of the soil plays an important part in the growth of trees.

Cannon (3) believed that differences in depth of root development are not directly due to differences in the soil or variation in the soil moisture. The various root types may be developed in soils that are uniform and suitably moist. The widely different root types are, in the main, the direct responses of the roots to temperature and to a less degree to the variations in the composition of the soil atmosphere which is associated with differences in depth. This is in harmony with the results of Oskamp and Batjer (20) and with that of Cannon (2).

Holbert and Koehler (9) made a study of the anchorage and extent of corn root systems in which they found that the habits of root growth as well as those of shoot growth are more or less characteristic of the plant. The roots are governed, first of all, by the hereditary growth characters of the species or variety in question. It has been shown that the inbred strains of corn differ greatly in the character and extent of their root systems.

Roberts (24) and Swarbrick and Roberts (26) found that the development of the root system of the apple is influenced by partial defoliation, also by the variety of cion which is grafted on the seedling roots.

Less (16), in his observations on root development, states that seasonal variations lead to variations in root development, the more uniform root development resulting from a season favorable for growth.

According to Cullinan (5), the root development of apple trees is greatly influenced by cultural practices such as cultivation and mulching. He found that apple trees grown under heavy straw mulch had different root habits from those grown under cultivation. In contrast to the depths of roots under cultivation was the shallow root system of the trees under the straw mulch. Here they came very close to the surface of the soil. In fact, roots half an inch in diameter or larger and many fibrous roots were found on the surface of the soil and penetrating the decaying material.

Green and Ballou (6) found that by annual plowing and clean cultivation it is possible to keep the root system of trees at greater depth in the soil where it will be less likely to suffer from extremes of drouth, heat, and cold. These workers also found that under the "Sod-Mulch System" of culture the trees have uniformly made a heavier, more vigorous growth than under any other system of culture. This is due to the certainty and uniformity of the generous store of fertility right at hand, the concentration of plant food where it is most available, and the consequent presentation of conditions, beneath the mulch of vegetable matter, especially favorable to a healthy, unstinted, continuous nourishment of trees.

Weaver (31) states that the development of roots of field crops is greatly influenced by such environmental factors as soil type, height of water table, and especially fertilization.

In digging wells, Jones (12) states that the presence of roots far down in the subsoil has been noted, and in the cultivation of fields adjacent to orchards, roots have been found at considerable distance from the trees. Facts thus gathered have indicated the extent to which roots may go; but little attempt has been made to determine how far they usually go, or how they are distributed throuth the soil.

After a study of apple trees, Jones (12) also states that there is a much larger amount of small roots close to the trunk of the tree than has been generally believed. As a rule there is a regular decrease from the base of the tree to the "eaves". Jones attempted to obtain the total length of the root system by measuring the roots found in each cubic foot of soil taken up.

Ballantyne (11) in working on fruit tree root systems found that the depth may be similar to the height of the tree. He further states that fruit trees ordinarily may be expected to send their roots deeply into the ground if the water supply is not too plentiful, especially near the surface. His method was to dig a trench around the tree at radial distances of five feet from the tree and then follow the roots to their ends.

Peren (23) found that from the results of the relatively small number of root systems examined it is evident that in the case of healthy material there must be considerable lapping of the root systems of permanent trees at the distances at which a large percentage of both dwarf trees and standards are planted in England. He worked mainly with the lateral spread of the root systems of apple trees.

Kolesnikov (13), working with apple tree seedlings, found that the depth, length, and number of roots undoubtedly depends upon the variety, soil, and environmental conditions. His investigations have demonstrated the regularity of the root development throughout the season, and has shown that young seedlings do not produce many long roots which penetrate great distances.

Rogers (25), working with one apple tree in a wet clay soil, found that the nature of the soil is undoubtedly responsible for the tree and root performance.

On digging away the soil around the tree trunk to a depth of 40 cms., Rogers found one or two fairly shallow roots. The majority of the roots were seen to be striking downward. The depth distribution of the roots and the sharp turning of the vertical roots below the trunk show that the root evidently would not tolerate constant immersion in water. He also found that roots extend even farther laterally than the branches.

Laitakari (15) states that the diameter, shape, and arrangement of the roots are influenced by the direction of prevailing winds in the summer.

Haasis (8) found that the form of roots developed by seedlings of Western Yellow pine varies according to the type of soil. The roots are longer in clay and shorter in loam. The greatest branching occurs in cindery soils and the least in a clay soil. In general, the greater the available moisture, the shorter is the root, and the greater is the ratio between the top and the root.

Moore (18) found that the seedling of Pinus resinosa, Pinus rigida, and Pinus banksiana developed a much greater root system when grown on humus than they did on sand or on a mixture of sand and humus. It is difficult to explain the cause of these results and of those of certain other investigators, but many more attribute the favorable effect of humus to its nitrogen content.

Holch (10) studied the growth of roots and shoots of deciduous trees on three classes of sites. Working with seedlings one to three years old, he found that growth was directly correlated to photosynthetic activity and inversely proportional to the available water content of the soil. The form of roots developed appeared to be hereditary with the species and to be more or less correlated with moisture conditions in the locations naturally occupied by that species.

It is known that root systems have a two-fold function. They at once afford safe anchorage and support and, at the same time, are the means by which water and inorganic materials are acquired. Cannon (4) makes a distinction between root systems of flowering plants as to the character of the terminal roots. Plants having fine terminal roots that are richly branched and occupy a small soil volume are termed insentive root systems. Extensive root systems, on the other hand, are such as have coarse ultimate rootlets, are not branched, and occupy a relatively large soil volume.

Various methods have been used in making a study of the roots. Ten Eyck (28) states that the study of the growth and development of the roots of plants offers a wide and profitable field for investigation. Plant study in the past has been mainly above ground. Certain systems of planting and cultivation have been practiced because experience has shown they are best. The study of the soil and of the roots of crops explained some of the difficult problems of crop production and have contributed to more intelligent and profitable farming. Ten Eyck's method was the use of wires to keep the root systems of grasses in place while the soil was washed away with water by means of a spray.

Gemmer (7) found the amount of soil necessary to be removed to expose tree roots was large. The roots of one tree occupied an elliptical area of 150 square feet. The laterals branch from the tap root immediately below the root collar and in general occupy a zone from one to three feet beneath the surface. The feeding roots therefore had contact with the moisture and nutrients of approximately 50 cubic yards of soil. In uncovering the root system of a long-leaf pine, Gemmer washed the soil away by a stream of water from a fire hose. Due to the sandiness of the soil it was easily removed from the point of contact, but immediately settled when out of the direct force of the stream. To remove this loose sand a device based upon the principle of a jet-blower was built, whereby a stream of water was forced through a three-inch pipe and deposited it some 60 feet from the diggings.

Vater (30) working with the Scotch pine, the spruce, and beech, states that the root development of the trees of a given station cannot be judged by general rules, but that a system of measurements must always be adopted. He felled the trees first and dug along two main horicontal roots, also digging a trench to allow vertical inspection of the position of the roots.

A method of obtaining roots in their natural surroundings in the field is given by Koval (14) as including three operations: eliminating the soil particles by help of a pressure draught; coordinating the positions occupied by the roots in the soil; collecting the roots and making a plan of their vertical arrangement.

In a review of literature on root studies, Miller (20) gives: (a) the extent of the root systems, including the method of isolation; (b) the relation of the weight of roots to the aerial portion of the plant; (c) the influence of moisture, fertilizers, and oxygen on growth and development.

MATERIALS AND METHODS

The root growth of apple trees reported herein was observed in the Kansas Agricultural Experiment Station Orchard during the fall of 1932. Five trees were selected including three Delicious, one Grimes, and one Stayman. The trees were about 16 years old and were planted 30 feet apart in rows that are 35 feet apart.

Studies were made of roots under two systems of soil management. Briefly, the treatments which the soil had received were as follows:

1. A clean cultivation cover crop system of soil management was inaugurated in 1921 and has been practiced

since. The principal cover crops used have been rye and winter vetch. An average of ten cultivations has been given the soil annually.

2. Trees in straw mulch rows received an annual application of straw about four inches thick. The straw was spread as evenly as possible under the trees and out beyond the tips of the outside branches, or a width of about 35 feet. The yearly accumulation of the decaying straw formed a heavy mulch.

The soil slopes rather irregularly to the north and west, there being a difference of about 70 feet in elevation between the lowest and the highest points.

The soil profiles in the Station Orchard vary with the elevation, and locally with respect to the drainage and erosion. In general the soil has been mapped by the soil survey as the Oswego Series, the profiles of which retard the development of deep rooting.

The excavation of the root system of a fair sized tree is itself no small problem.

In order to get a view of a portion of the root system in its relation to the soil profiles, about one-third to one-half of the root system was exposed in each of four trees; and the whole system in the fifth.

The soil was removed at the crown to a depth of six inches or more and the roots were carefully followed outward to their tips.

This excavation made it possible to observe the appearance and extent of the root systems and also facilitated photography. As the roots were exposed, the diameters at three foot intervals were recorded as well as the depth below the surface.

Drawings of the root systems were made in the field soon after the roots were excavated. In the drawings the root systems were arranged as nearly as possible in their natural position.

DESCRIPTION OF TREES AND SOIL PROFILES

The root systems of five bearing trees 16 years old were exposed and examined. The description of each tree and the soil profiles are given below:

Tree No. 1. Tree No. 1 was Grimes, 16 years old. It was located in row 33, tree 8 in the row. At the time the root system was examined the tree was 20 feet tall and had a branch spread of about 26 feet. This part of the orchard had received an average of ten cultivations with a disk annually between 1921 and 1930. Vetch or rye cover crops were seeded about the first week of September, and plowed under the following May. Since 1930, grass has been permitted to grow to reduce soil erosion.

Due to the claypan subsoil and the impenetrable rocks under the tree which were encountered at the depth of 25 inches, the direction of the growth of the roots was nearly horizontal or sloping gently downward.

The greatest amount of roots was found 16 inches to 30 inches below the surface of the soil. The lateral root spread extended about 39 feet from the trunk of the tree.

The plan of the roots of this tree (Plate IX) reveals the large extent of its root system. Some of the roots followed the course of a ditch as though reaching for a supply of moisture.

The depth to which the root system extended can be seen in Table I. Plate I shows the shallow distribution of the roots of this tree, and the way in which one root, one and one-half inches in diameter, grew down in the soil. One lateral root extended horizontally 35 feet from the tree and then turned abruptly downward to a depth of 74 inches.

Description of the Soil Profile for Tree No. 1

Horizon A(1) is practically gone, and horizon A(2) is about 10 inches in thickness. The soil is light gray, is fairly loose, and is classed as silty loam. No roots were encountered in this layer.

Horizon B is compact, about 14 inches in thickness, is not thoroughly leached and has no well developed structure. It contains numerous yellowish brown concretions, probably iron. The soil is classed as silty clay loam. Most of the lateral roots of this tree were found in the B horizon, all sloping gently downward.

Horizon C is made up of calcareous materials in various stages of disintegration. The thickness is variable. It is light, rather loose, and is classed as sandy clay loam. Only one vertical root was encountered in this layer, though some of the lateral roots in the B. horizon had extended their tips into this horizon.

Tree No. 2. Tree No. 2 was a 16 year old Delicious, row 20, tree 12. It was 17 feet tall and had a branch spread of about 26 feet. Tree No. 2 had been under the straw mulch treatment for 11 years when the roots were examined. This soil was badly eroded and the remaining subsoil was heavy clay.

Roots of this tree from one-fourth to one-half inch in diameter and also fibrous roots were found four inches beneath the surface of the soil. The greatest portion of the root system was from five to 25 inches below the surface of the soil. Nearly all the roots were found growing in a generally horizontal plane and those lateral roots which grew to the edge of the straw mulch turned abruptly downward at that point. This was evidently brought about by the favorable moisture conditions near the surface of the soil under the straw mulch and at greater depths beyond the mulch. The largest lateral root extended for a distance of 34 feet under the straw mulch and in a direction parallel to the row of trees. A plan of the root system of this tree is shown in Plate X. It is not at all clear why the roots have grown more profusely and farther in some directions than others. Slight variations in the soil and chance distribution of roots when the tree was planted may account in part for this irregularity.

It does not appear that a root will necessarily avoid soil that is occupied by another root, for in some cases several roots were found growing almost parallel and very close each other. Sometimes when a root branched, the two branches grew along together for some distance, which seems to indicate that some particularly congenial condition may have occurred in that part of the soil.

Two roots penetrated through the claypan, B horizon, down to the C horizon.

Description of Soil Profile for Tree No. 2.

The soil on which tree No. 2 was growing has the following profile:

Horizon A has been nearly completely removed by erosion.

Horizon B has an average thickness of 15 inches. Horizon B has been exposed, is light gray, and is classed as silty clay loam.

Many small roots one-fourth to one-half inch in diameter and also fibrous roots were found in the B horizon, four inches below the surface of the soil, feeding in the decayed organic material. A great number of the roots were in the first 15 inches of soil with numerous branch roots extending horizontally 15 feet, to the edge of the straw mulch, before turning downward.

Horizon C is of indefinite thickness. The soil is light gray, rather loose, and is classed as sandy clay loam. The lateral roots in the B horizon have extended horizontally 18 feet or more. Only two vertical roots, however, were found in the C horizon.

<u>Tree No. 3</u>. Tree No. 3 is another 16 year old Delicious, located in row 17, tree 19. It was about 19 feet

tall and had a branch spread of about 26 feet. The soil has been under clean cultivation-cover crop management for 12 years.

The root system of this tree was similar to that of tree No. 1 and reached a depth of about 48 inches. The maximum lateral root spread extended about 39 feet from the trunk of the tree. Most of the roots were in the top 20 inches of soil. The deepest root terminal was 45 inches deep. The roots varied in length between 10 and 39 feet. There were a few fibrous roots and small branch roots that came from roots cut by cultivation.

The downward penetration of the roots through the B horizon followed the shrinkage cracks developed when the soil underwent drying. The roots form fanlike fine roots growing parallel with the blocks of hard clay. The structure of the B horizon is slightly developed and where sufficiently pronounced is classed as "fine granular". In the case of the coarsest structural units, the structure is "nutty".

Description of Soil Profile for Tree No. 3.

The soil profile on which this tree is located has the following characteristics: The surface of the soil has been eroded until only about three inches of horizon A remain. It is light gray and is classed as silty loam.

Horizon B(1) is about four inches thick. It is heavy and plastic, but it has not developed a pronounced structure. Horizon B(2) has an average thickness of 16 inches. It is heavy and darker in color than horizon B(1) or horizon A. There were some iron concretions in it. This horizon is classed as light gray silty clay loam. Its structure is more fully developed than that of B(1). The roots were situated in the B horizon with the exception of one root which went down to the C horizon to a depth of 48 inches.

Tree No. 4. Tree No. 4 was a 16 year old Stayman, located in row 57, tree 17. It was 20 feet tall with a branch spread of 26 feet. The soil management has consisted of cultivation-cover crops, as for tree No. 3. This tree is located at the lowest point in the orchard in which alluvial material has accumulated to a depth of 43 inches.

The greatest portion of the root system of this tree was found between 35 and 55 inches below the surface of the soil, with a lateral spread of about 27 feet. This tree had smaller and deeper lateral roots than the other trees (1, 2 and 3). It had only a few branch roots and hardly any fibrous roots.

Data descriptive of the root system of this tree are shown in Table I. Plates VI and IX reveal the depth of root penetration of this tree. The reason for this depth is probably the desirable physical conditions of the soil, together with a sufficient amount of moisture which enabled the roots of this tree to penetrate deeply. One branch root with a diameter of about five-sixteenths inch grew from a depth of 38 inches up to 25 inches below the surface of the soil.

Description of Soil Profile for Tree No. 4.

The soil profile as revealed at this tree shows a "buried soil". An accumulation of alluvial material deposited comparatively recently with an average thickness of about 43 inches, has covered a previously developed profile. Underneath this layer is the original Horizon A, about 5 inches in thickness. It is light gray, and is classed as silty loam. The crown of this tree is 43 inches below the surface of the soil.

Most of the roots of this tree were found 35 to 55 inches below the surface of the soil.

Horizon B is approximately 10 inches thick. It was in the first stages of development when the alluvial material was deposited above, and the structure had begun to develop but had not become pronounced. There is evidence, on the outside of the aggregates, of material brought down from above.

The roots of this tree have grown down from the A to the B horizon. This characteristic of the roots was due perhaps to the favorable texture and structure of the soil, together with a sufficient amount of moisture. The roots of this tree have penetrated deeper than any other tree in the group. For illustration see Plate XII.

Tree No. 5. Tree No. 5 was a 16 year old Delicious, row 51, tree 17. It was 21 feet tall and had a branch spread of 28 feet. It has received the same cultural treatment as trees 3 and 4.

The root system of this tree was the poorest in the group. Most of the lateral roots were between 5 and 22 inches deep. Some of the roots were found to extend their tips 31 feet from the trunk of the tree.

There were a few fibrous roots at the crown and small branch roots that came from roots cut by cultivation. The deepest root terminal was 48 inches below the surface of the soil.

Description of Soil Profile for Tree No. 5.

Horizon A is about 20 inches thick and is of incomplete development. The soil is light gray, fairly loose, and is classed as gray silty loam. Most of the roots of this tree were situated in this layer except those branch roots that grew down to a maximum depth of about 48 inches.

Horizon B has an average thickness of six inches, and is immature in development. It is tight, plastic, light gray, and is classed as light gray silty clay loam. No significant structural development has occurred. Only a few roots were found in the B horizon. Some of the roots extended down the C horizon.

EXPERIMENTAL RESULTS

The final observations and measurements were made in the fall of 1932. Table I gives the treatment of the trees, row and tree number, variety, age, height, average branch spread, average depth, maximum depth, average and maximum lateral spread of the roots and condition of the soil on which the trees were grown.

Table I.

Treatment	Row	Tree number in row	Variety	Age	Height, feet	Average branch spread, feet	Region of greatest number roots, inches	Maximum depth of roots, inches	Average length of lateral roots, feet	Maximum lateral length of roots, feet	Condition of the Soil
Cultivated and Cover Crops	33	8	Grimes	16	20	26	27	74	23	39	Plastic and hard subsoil. Horizon A was 10 inches thick, gray. Horizon B not thoroughly leached with numerous yellowish brown concretions, probably iron.
Straw mulch	20	12	Delicious	16	17	26	21	66	23	34	Plastic and heavy. Horizon A completely removed by erosion. Horizon B has a fine structure.
Cultivated and Cover Crops	17	19	Delicious	16	19.5	26	18	38	28	48	Plastic and heavy. Horizon A is three inches thick. Horizon B has thickness of about 20 inches with some iron concretions.
Cultivated and Cover Crops	57	17	Stayman	16	20	26	60	76	20	27	Friable subsoil. Horizon A consists of alluvial deposit of about 43 inches. Horizon B is in the first stage of development with no pronounced structure.
Cultivated and Cover Crops	51	17	Delicious	16	21	28	22	48	21	31	Plastic and hard subsoil. Horizon A 20 inches thick of incomplete development, loose. Horizon B is six inches thick, is very immaturely developed. Not pronounced in structure.

<u>The Branch Spread.</u> The circles on the plans, see Plates 9 to 13 inclusive, represent the approximate spread of the aerial branches of these trees. With all the trees, the roots spread considerably farther than the branches. There has been no evidence found from the trees excavated to support the idea that the root system forms a reflection of the branch system in either direction, spread or depth.

<u>Influence of Soil Moisture on Root Development</u>. This root study indicates that soil moisture has a pronounced influence upon root development. In plates IX to XIII inclusive typical roots and soil profiles are presented with evidence that root growth was in every instance closely associated with available soil moisture. In a few cases where the soil was moist to considerable depths, the roots responded by extending their growth to such soil.

The typical roots and soil profiles give some idea of the influence exerted by the soil moisture on root formations. When roots find an abundance of moisture close to the surface as shown in Tree No. 2 they branch freely through the surface soil, and show little tendency to go deeper, particularly if conditions are more and more unfavorable for root development at greater depths.

Compact or water-logged subsoils such as are in parts of the station orchard, prevent the roots from penetrating deeply (Tree No. 3).

The average and maximum depths and spread of the roots under the orchard conditions are shown in Table I.

Data from these root studies indicate that moisture content and aeration in the soil are two of the controlling factors that influenced root growth of these trees.

During the course of excavations close observations have shown that roots penetrated the B horizon by following the shrinkage cracks between the blocks of hard clay and form threadlike branch roots. These fine branch roots spread like a fan parallel with the blocks of hard clay.

These root characteristics were shown by trees No. 1, 2, 3 and 5.

Plate I. Tree No. 1, Grimes, planted in 1916. Photographed November 26, 1932, showing shallow root system. Penetration was restricted to the surface soil because of the resistant clay-pan B horizon.

Plate I

Plate II. A root of the tree in Plate I which penetrated down to the unweathered C horizon, where moisture was reached. Photographed November 26, 1932.

Plate II

Plate III. Tree No. 2, Delicious, planted in 1916. Photographed February 26, 1933, showing the lateral root which grew to the edge of the straw mulch and turned abruptly downward at that point.

Plate III

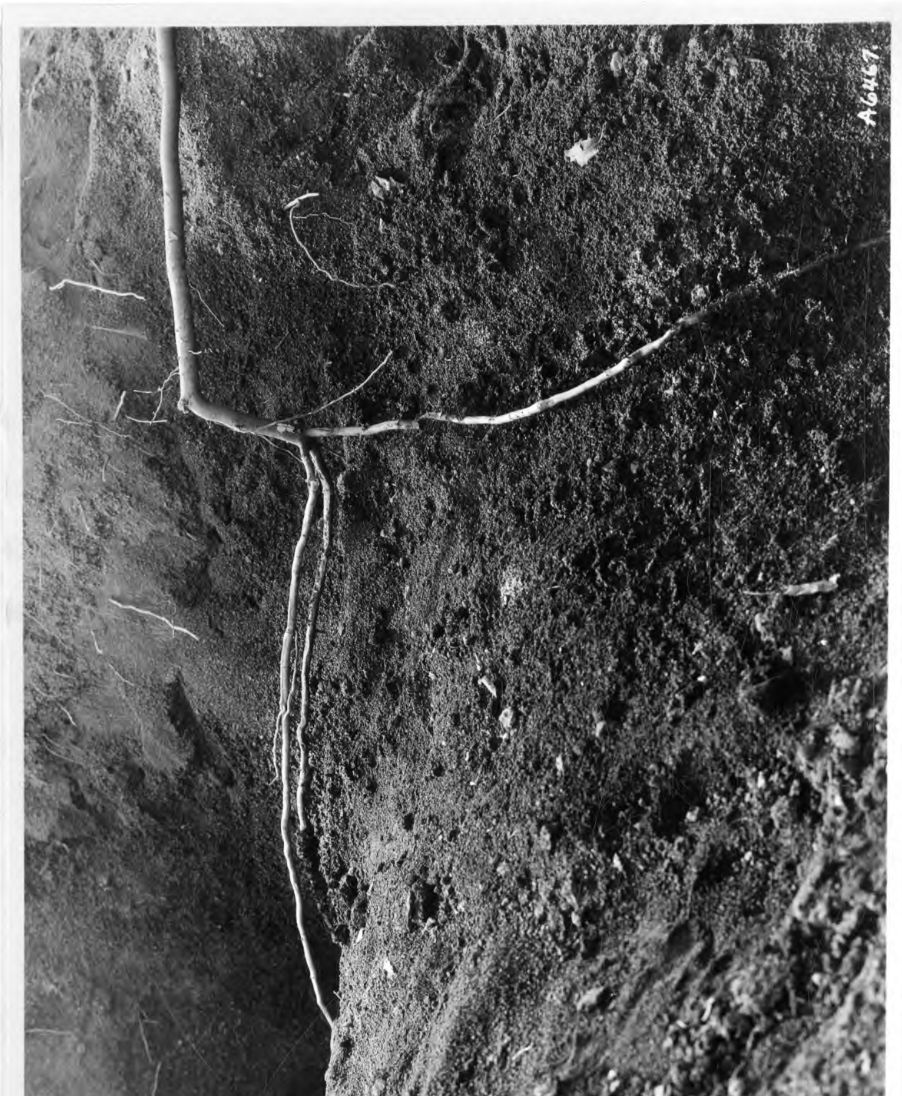

Plate IV. Tree No. 3, Delicious, planted 1916. Photographed February 26, 1933, showing the shallow root system due to resistant claypan B horizon.

Plate IV

Plate V. One of the shallow roots of the tree shown in Plate IV. Note that this root (in the foreground) grew down through the B horizon into the claypan C. horizon. Photographed February 26, 1933.

Plate V

Plate VI. Tree No. 4, Stayman, planted in 1916. Photographed February 26, 1933, showing the deeply penetrating root system in a deep alluvial soil. The roots of this tree penetrated to a maximum depth of 76 inches.

Plate VI

Plate VII. Tree No. 5, Delicious, planted in 1916. Photographed February 26, 1933, showing the shallow root system due to resistant claypan B horizon.

Plate VII

Plate VIII. Photographed February 26, 1933. The same tree as in Plate VII, showing the long shallow spreading roots.

Plate VIII

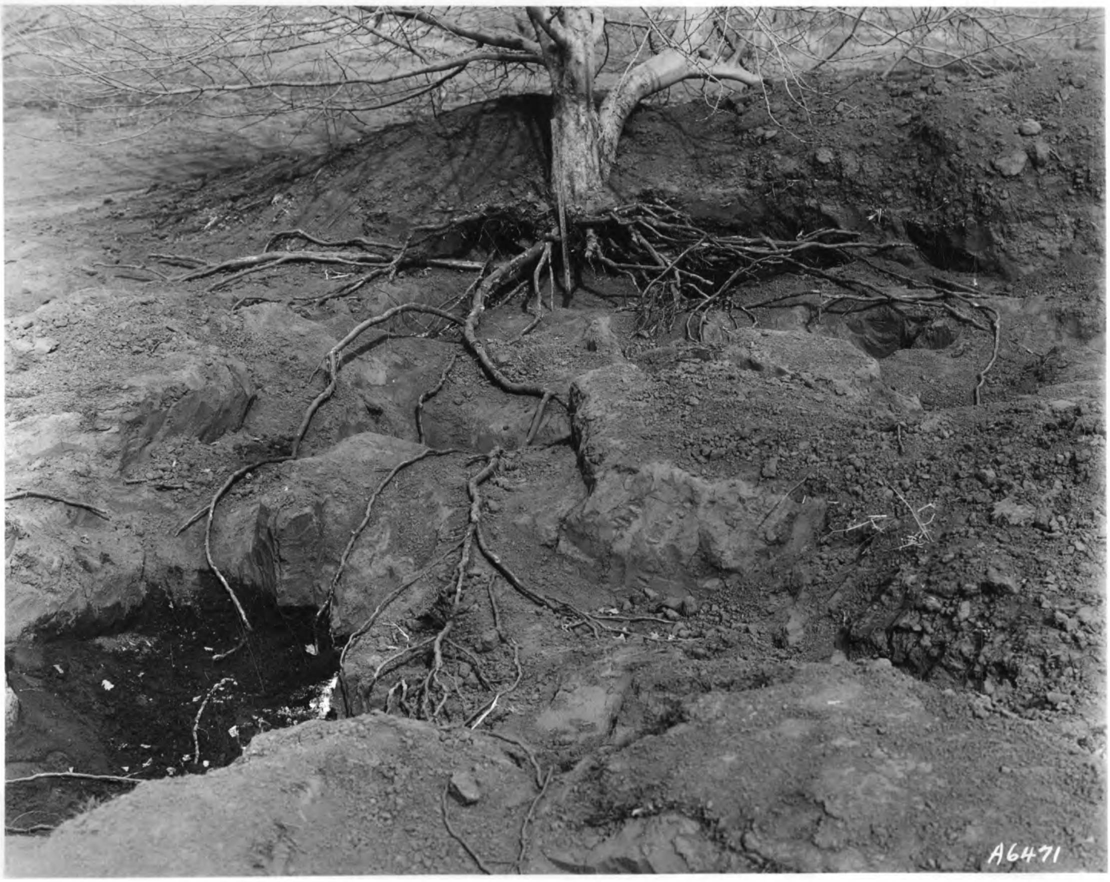

Plate IX

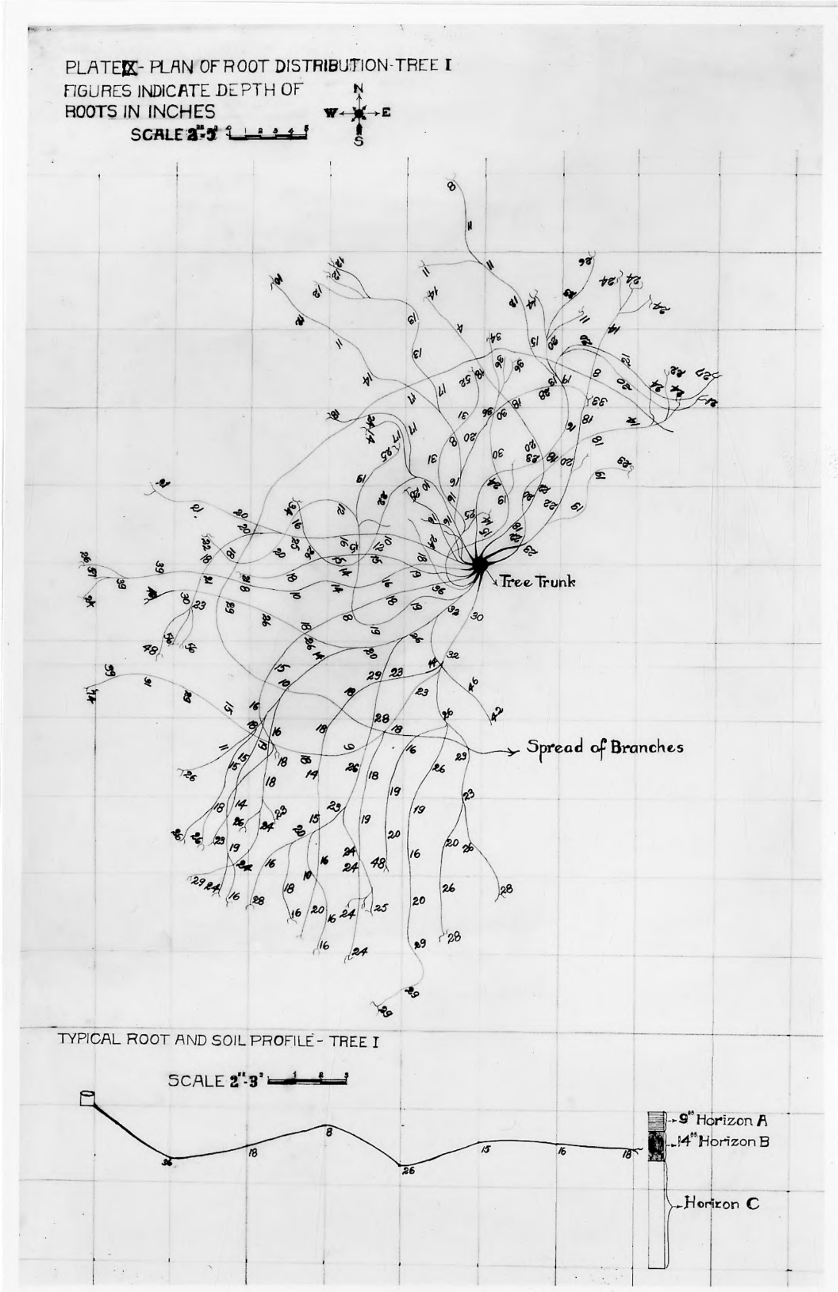
PLATE IX - PLAN OF ROOT DISTRIBUTION - TREE I
FIGURES INDICATE DEPTH OF
ROOTS IN INCHES
SCALE 2"-3'
N
W
E
S
Tree Trunk
Spread of Branches
TYPICAL ROOT AND SOIL PROFILE - TREE I
SCALE 2"-3'
9" Horizon A
14" Horizon B
Horizon C

Plate X

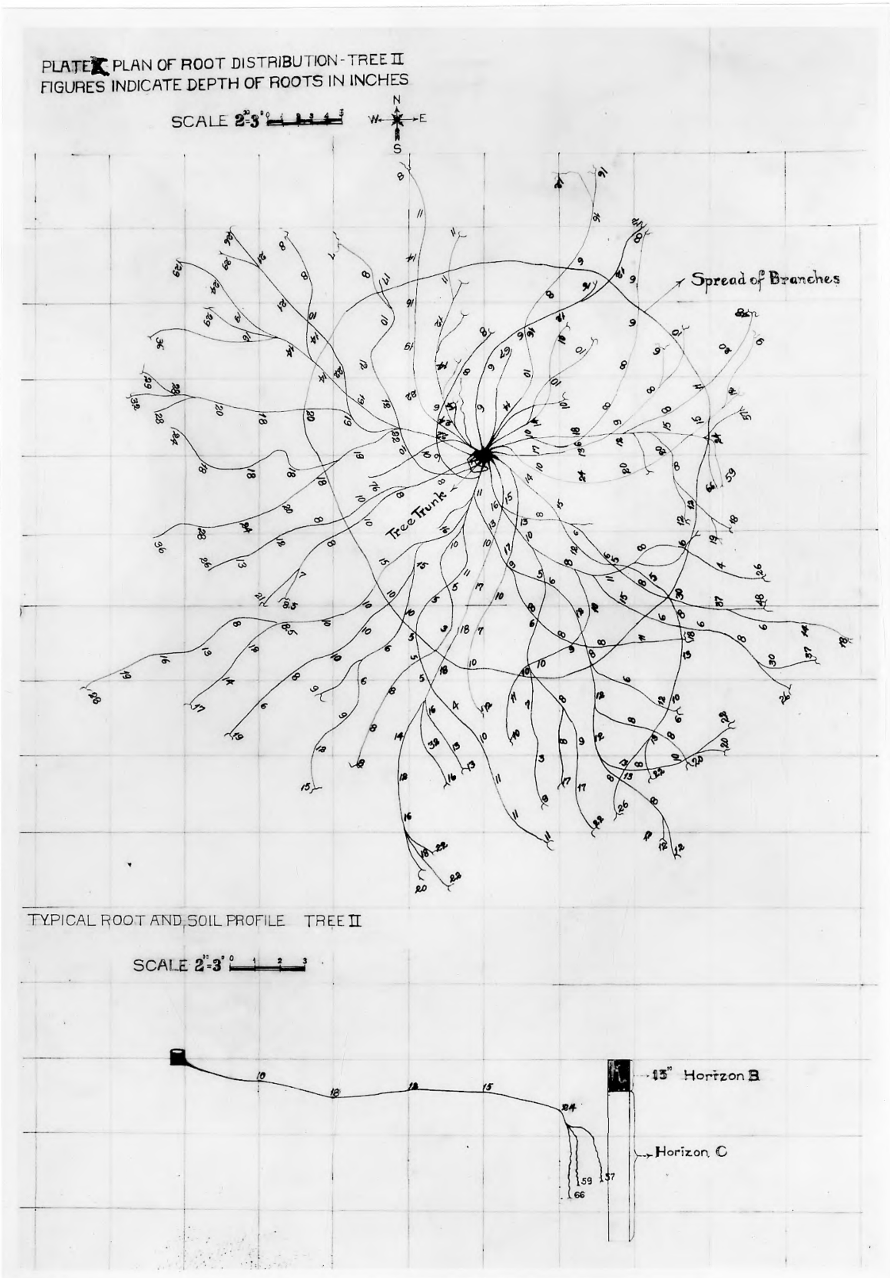
PLATE X PLAN OF ROOT DISTRIBUTION - TREE II
FIGURES INDICATE DEPTH OF ROOTS IN INCHES
SCALE 2"=3'
N
W
E
S
Spread of Branches
Tree Trunk
TYPICAL ROOT AND SOIL PROFILE TREE II
SCALE 2"=3'
13" Horizon B
Horizon C

Plate XI

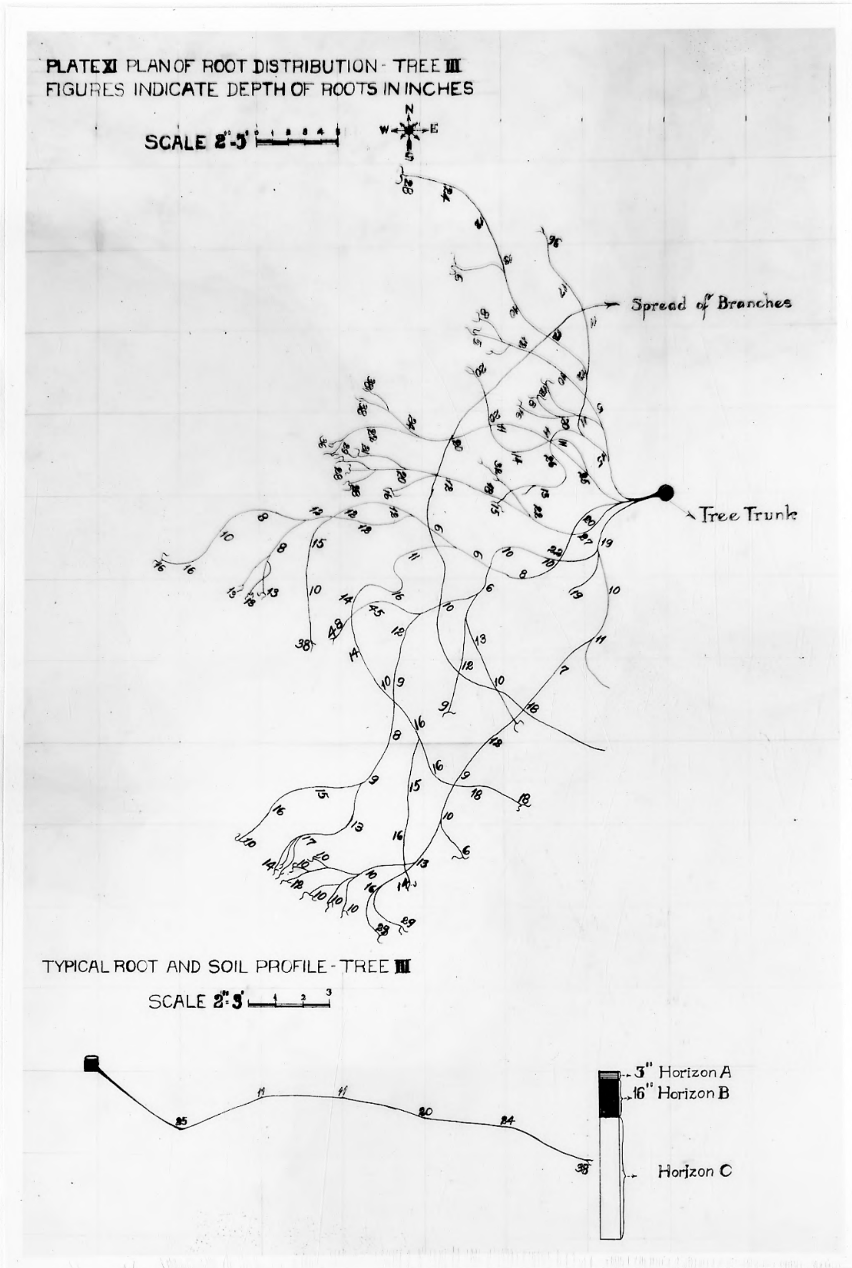
PLATE XI PLAN OF ROOT DISTRIBUTION - TREE III
FIGURES INDICATE DEPTH OF ROOTS IN INCHES
SCALE 2"-5'
N
W
E
S
Spread of Branches
Tree Trunk
TYPICAL ROOT AND SOIL PROFILE - TREE III
SCALE 2"-3'
3" Horizon A
16" Horizon B
Horizon C

Plate XII

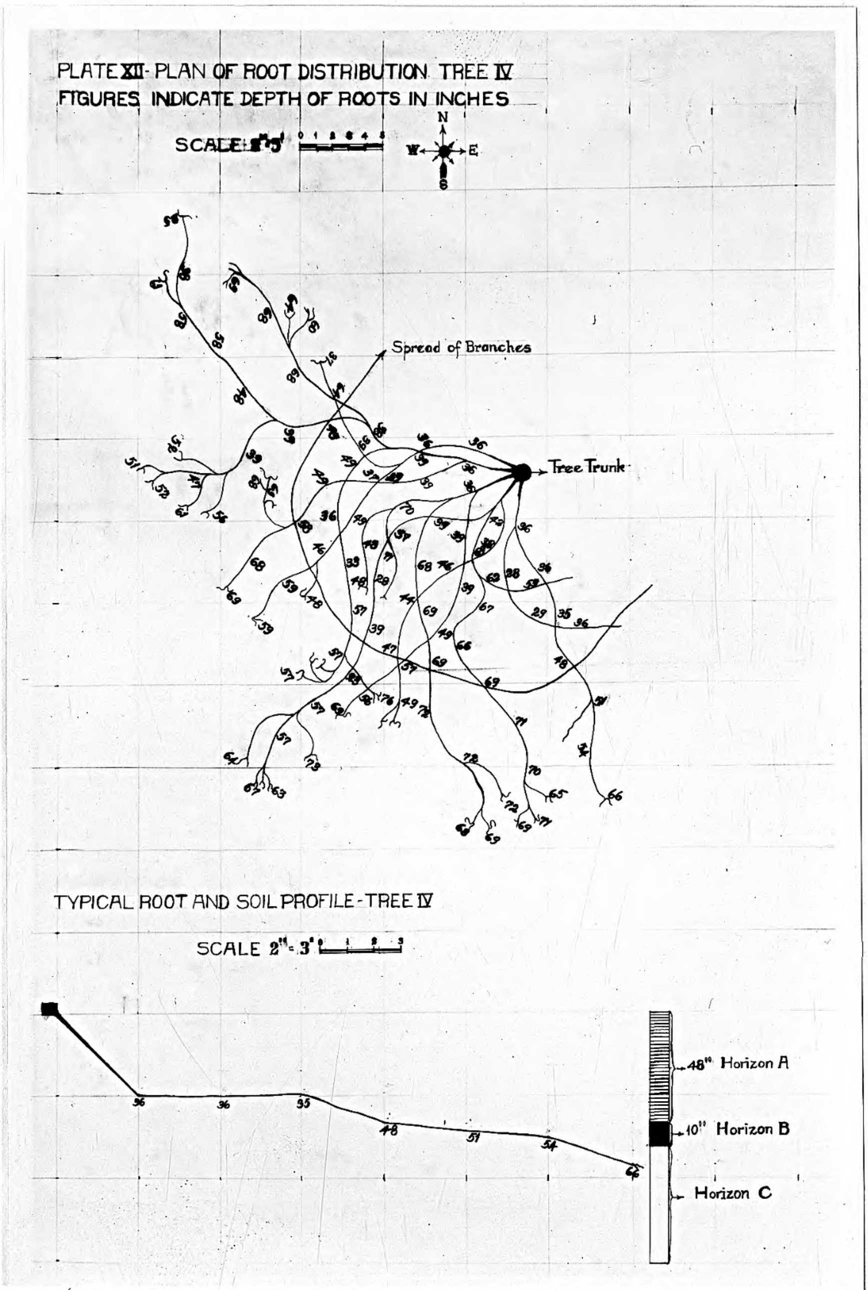
PLATE XII - PLAN OF ROOT DISTRIBUTION TREE IV
FIGURES INDICATE DEPTH OF ROOTS IN INCHES
SCALE
N
W
E
S
Spread of Branches
Tree Trunk
TYPICAL ROOT AND SOIL PROFILE - TREE IV
SCALE 2" = 3'
36
36
35
48
51
54
66
48" Horizon A
10" Horizon B
Horizon C

Plate XIII

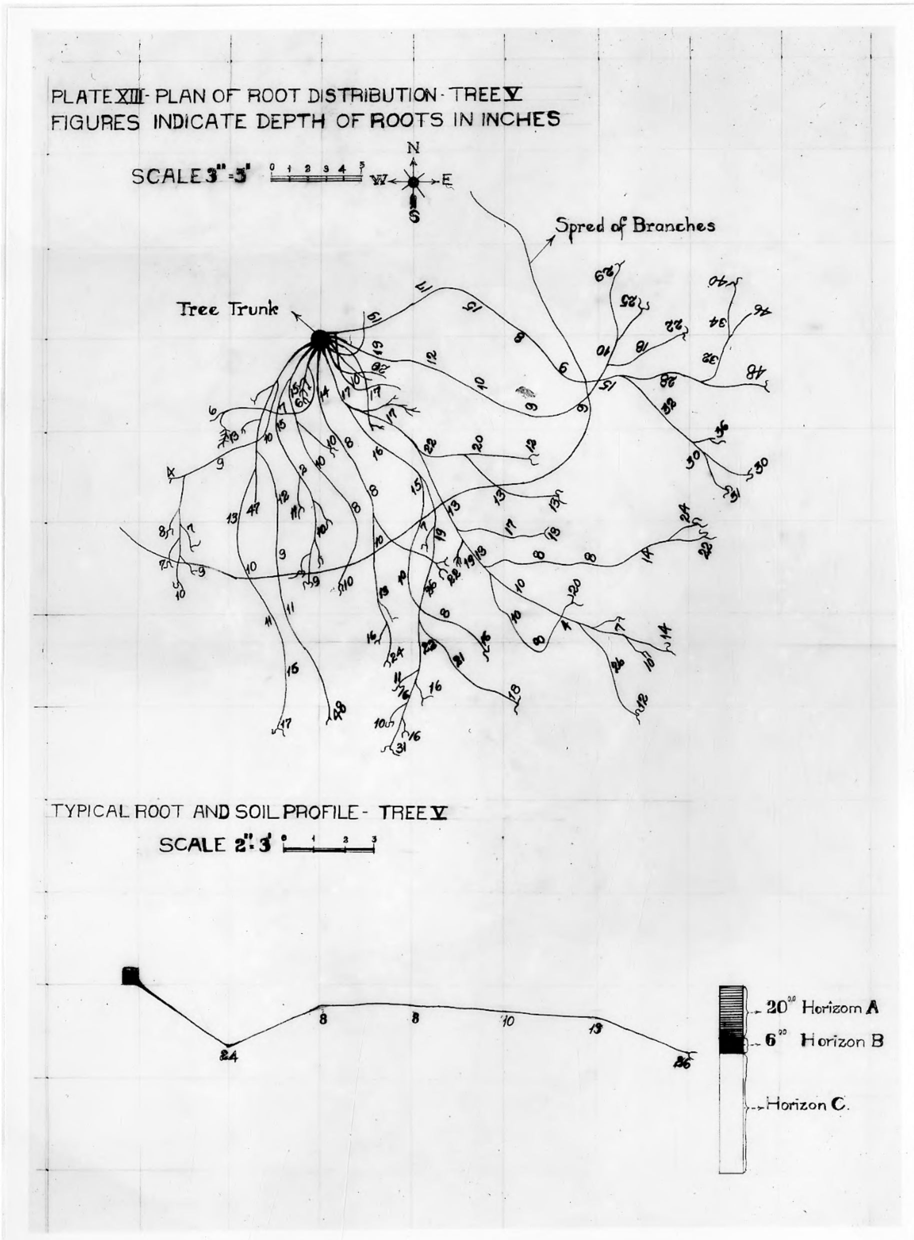
PLATE XIII - PLAN OF ROOT DISTRIBUTION - TREE V
FIGURES INDICATE DEPTH OF ROOTS IN INCHES
SCALE 3" = 5'
N
W
E
S
Spred of Branches
Tree Trunk
TYPICAL ROOT AND SOIL PROFILE - TREE V
SCALE 2" = 3'
20" Horizom A
6" Horizon B
Horizon C.

SUMMARY

1. The root systems of five bearing trees, three Delicious, one Grimes and one Stayman, were excavated in the Kansas Agricultural Experiment Station orchard, at Manhattan, in the fall of 1932.

2. Studies were made of roots under two systems of soil management, namely: (1) A clean cultivated cover crop system of soil management which was inaugurated in 1921, and has been practiced ever since. The principal cover crops used have been rye and winter vetch. An average of ten cultivations has been given the soil annually. (2) Straw mulch system of soil management in which the trees in the straw mulch rows received an annual application of straw about four inches thick. The straw was spread as evenly as possible under the trees and out beyond the tips of the outside branches.

3. The roots of the trees in the cultivated soil, with the exception of tree No. 4, (Plate VI) which was located at the lowest point of the orchard, and at which point alluvial soil has accumulated, were found at a shallow depth. Tree No. 4 has smaller and deeper lateral roots

than other trees in cultivated soil. In one instance a branch root about the diameter of five-sixteenths of an inch came from a depth of 36 inches up to about 12 inches below the surface of the soil. Desirable physical condition of the soil, together with a sufficient amount of moisture has enabled the roots of this tree to penetrate deeply.

4. The root development of the trees has been relatively shallow with a wide lateral spread.

5. The lateral roots spread considerably farther than the aerial portions of the tree.

6. The lateral roots were entirely or almost wholly in the clay pan B horizon, and frequently extend horizontally 18 feet or more before turning down.

7. The roots penetrated the B horizon by following the cracks between the blocks of clay, and formed thread-like roots.

8. Root development depended on the amount of moisture of the soil, resistance of the soil layers, aeration of the soil in which the tree was growing, and the system of soil management.

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