Bulletin No. 143 - Fruit Tree Root Systems: Spread and Depth

A. B. Ballantyne
Fruit Tree Root Systems
Spread and Depth

As Partly Determined by Excavations on the Southern Experiment Farm, St. George, Utah

BY

A. B. BALLANTYNE

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UTAH AGRICULTURAL EXPERIMENT STATION

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FRUIT TREE ROOT SYSTEMS
BY A. B. BALLANTYNE.

INTRODUCTORY.

As mentioned in Utah Station Bulletin No. 124, seepage conditions on the Southern Utah Experiment Farm were responsible for the removal of about 5 acres of vineyard in 1908, and 7 acres of mixed peach orchard in 1910, all of which were on the lower or western half of the farm.

These orchards and vineyards had always received good care, clean culture being practiced in fact as well as name. The results for a number of years were all that could be desired, when the trees and vines began to die questions arose as to the cause, since in spite of a reduced number of irrigations the trouble grew rapidly worse. Before removing the orchard in 1910 two lines of investigation were undertaken. The purpose was to gain some idea of the conditions then existing in the soil and further to determine how these and other possible conditions had caused the trees and vines to die.

Accordingly it was decided to dig up some fruit trees, to follow and map their main roots, note their condition and determine their general spread and depth. The other line of investigation was to bore some wells on various parts of the farm and note the behavior of the water level in these under the various seasonal conditions.

While this work has been entirely localized and is the analysis of a peculiar condition, yet the soils dealt with and the seepage conditions encountered are in some degree typical of many of those of the western sections.

This first part has long been completed and was held awaiting the completion of the well measurements before being published.

The trees selected from the orchard on Plat C were an Elberta, a King Prize Peach, and a Winter Bartlett Pear, and for comparison a Jonathan apple and a Thompson Seedless grapevine both from Plat D.

The work was confined to following only the main roots and their larger branches to their ends if possible. It was impossible in the time available to follow all the roots to their ends. Especial attention was given to those roots going downward and as a result most of the laterals or the roots lying near the surface were cut off before their ends were reached.
Sometimes the roots were accidentally broken off near their ends and thus lost. At other times, as before stated, they were intentionally cut because of the proportions to which the work was growing. While this renders the results more or less incomplete, yet, a general idea of the root development under those conditions of soil and culture has been obtained as well as the effects which the changing soil conditions have had on them.

The soil in which the trees were growing, was of a sandy clay on the surface, underlaid by almost pure sand that was more or less honey-combed with large clay cells. This general structure seemed to hold for practically all of the soils examined in removing the roots, both in location and depth.

In the process of uncovering the roots, a trench was first dug about two feet from the tree, and with the exception of the Winter Bartlett pear and Thompson Seedless grape vine, was on the west side. This trench was semi-circular in outline with a five foot radius and was first dug about five feet deep. With the exception of the King’s Prize tree, any large roots found in this trench were left and followed.

After the trench was dug, a long board was nailed to each side of the tree at the surface level of the ground and as nearly as possible in a north and south line. The middle line of these was used as one axis. All roots followed were located at each bend or turn with reference to these axes and the distance from the surface, and were so placed in the accompanying charts or graphs.

The work of uncovering the roots was more or less tedious, because it was almost impossible to use anything to loosen the earth, but a sharp pointed iron, though for much of the rougher work, a stable fork was used. As the earth was loosened from the roots, it was brushed into the pit and from there removed.

No attempt was made to preserve the smaller branches and rootlets, as this would have been impossible unless water under force had been used. We are only concerned with the larger roots and their main branches.

All of the roots were followed, carefully examined and where a portion of them had died this was recorded and later indicated on the charts.

In graphing the roots, one of the methods employed in descriptive geometry was used. That is the Horizontal Projection
or Spread represents the position of the roots with reference only to the cardinal points and of course thus could not represent depth.

In the Vertical Projection is represented the depth as well as the position on the north and south sides of the tree, but does not show the distance on the east and west sides.

This view was used to show the relationship existing between the spread and the irrigating furrows which were in an east and west line.

It may be well in this connection to say that for the first few years a single furrow on each side of the trees supplied moisture. After five or six years, however, one more was added to each side and these two were within four feet from the base of the tree.

**King's Prize Peach.**

The accompanying illustration of the root system of this tree shows it to be apparently one-sided. This was not actually the case, as six fairly large and two smaller roots were cut off when the trench was dug. One of these were larger than Nos. 2, 3 or 7, and to all appearances, they lay near the surface, apparently not going deeper than two or three feet. They represented probably not more than a third or a fourth of the entire system.

This peach tree was number eight in the row and as far as one could judge, was perfectly healthy. The trees north, south and west had died during the summer, while those east, were healthy; so that this tree stood on the division line between the good and the seeped ground. This tree in all probability would have died before any of those on the same row immediately east of it. The condition of the roots, therefore, may serve as an illustration of the way in which the rest of the trees died.

The work of uncovering the roots was done in the middle of October, after the rains of September.

**Condition of the Soil.** At this time, the soil was moist enough for plant life below the first spading. This was probably due to the seepage conditions, although the water table was 8 feet, 11 inches from the surface, when the trees was dug up.

It may be noted here that two relatively compact strata of earth were encountered at 3 feet 2 inches, and 8 feet 5 inches, respectively, the lower one being six inches thick. Touching the
lower side of this was the water. The rest of the soil was uniformly loose sand with occasional streaks of clay which lay in various positions without any relation to each other.

**The Root System.** A glance at the horizontal projection shows that the development of the system was by no means ideal, there being a marked deficiency in the number and length of the roots on the north-eastern and eastern sides, while the development on the south side is very pronounced, and had those roots been followed to their ends, the difference would have been even more marked. Root No. 8 was followed a distance of 6 feet 9 inches, south of the tree. It had attained a depth of 4 feet 10 inches at that point. It is probable that the total spread south of
the tree was 8 or 10 feet compared with 4 feet 2 inches for the north side.

Root No. 6-1-1, it may be interesting to note, left No. 6-1 at a point 1 foot 2 inches in depth, 2 feet 10 inches south and 1 foot 7 inches east of the tree. It went down to 1 foot 9 inches from the surface, then gradually came up until it was but 4 inches from the surface and then went down again to a depth of 1 foot 8 inches. It followed the course of the irrigating ditch for about 5 feet and then back again.

The first thing that attracts our attention upon a glance at the vertical projection is the large number of dotted lines or indicated dead roots or parts of them. Of the seven roots reaching down 9 feet or lower, but one is alive to the tip; and even at 5½ feet, six out of eight roots are dead.

One root (No. 1-3) is dead at 1 foot 10 inches, its junction with the large root; while two more are dead at 2 feet 2 inches and 2 feet 5 inches, respectively.

If the seepage conditions alone, therefore, without considering the possible influence of alkali, are responsible for the death of these roots, then the water table must have stood somewhere between 5½ feet and 2 feet below the surface, and this for a single time long enough to suffocate the roots.

The fact that the main root of No. 1 was alive to its tip indicates that this root may have grown since the water table had lowered. The root itself beyond the branch No. 1-2 was smaller than a pencil and might easily have grown in two seasons.

In general, the roots, excepting No. 6, were about an inch in diameter a foot from the trunk, and possessed but few small roots, such as we might class as feeders. They possessed more than the Elberta roots but relatively few compared with those of the Winter Bartlett pear and Jonathan apple.

We may say that the root system of this King’s Prize peach tree was distinctly a deep feeder.

**Elberta Peach Tree.**

This tree was No. 2 in the row and was healthy, though not thrifty, the leaves being slightly yellowish in color, but otherwise there was no perceptible difference between this tree and the other healthy trees of the orchard.
The trees adjacent in the row were both healthy, while the tree immediately south had died during the summer, though the ones on either side of that were still alive. On the north side at a rod's distance was an Osage Orange hedge that was about 9 years old and which for the past four or five years had grown wild. Its roots extended entirely across the pit that was dug in removing the tree.

**Condition of the Soil.** The tree was dug up in the latter part of September and the fore part of October, and though there had been rains during September, yet the first 14 inches of soil was extremely dry and hard; so hard in fact that it was difficult to break without using a pick. For two feet below this, the soil
was almost pure sand and so dry that it would run. Below this, it became moister and at 5 feet, if squeezed in the hand would remain in a ball.

The general structure of the soil was the same here as elsewhere—loose sand with occasional streaks of clay in which numerous rootlets were invariably found.

In digging the trench, there was scarcely a rootlet and no large roots found so that almost the entire main system is shown. One peculiarity was noticed in removing these roots and that was that the third foot of soil was very well filled with small feeding roots while below and above there were scarcely any.

The Root System. The horizontal projection of this root reveals a widely spreading system, entirely of one sided development; and what is more remarkable, is that the roots reach out to the east as though reaching for the supply of moisture.

A further study of the vertical projection shows that probably three-fourths of the roots lie within the first two and a half feet of the soil and that only one goes deeper than five feet. This is not saying that more did not go deeper, but that of those followed only one went deeper. Besides only Nos. 2-2, 4 and 5 were followed to their ends, so that had all been followed the results might have been slightly different; though judging from the experience gained and the smallness of most of the roots when they were cut it is improbable that many went much deeper.

Upon comparing the root systems of the King's Prize and Elberta peach trees, one is apt to wonder why there is such a great difference in them: For the former is distinctly a deep feeder, while the latter is even more pronouncedly a shallow rooted system and thus a surface feeder.

We are told that peach trees demand a well drained open soil, the inference being that their roots penetrate deeply. The King's Prize root system certainly bears this out, but the Elberta did not. Of course the fact that one is King's Prize and the other Elberta does not offer any suggestion, as they were both budded trees. Then one of two things is evident, either the roots were of a different species or habit or there has been some difference either in soil or culture.

The problem could have been at least partly solved by digging up several other trees and comparing their root systems, but
inasmuch as that was not done, we must look at it in another way.

As before stated, the trees were budded ones and were secured in the same year from the Utah Nurseries. Whether the seedlings were home grown or not does not make much difference. They were both peach roots and were probably planted from the same stock of pits. Of course there will be some variation among individuals but hardly so much as illustrated under identical methods of treatment.

In the number and frequency of cultivations, both trees were treated practically alike, so that if the soil conditions, such as depth, structure and texture were similar, as they were—the only remaining cause must have been a difference in the amount or method of watering or both.

As already stated, the King’s Prize tree was No. 8 in the row and therefore 132 feet from the head ditch, while the Elberta was No. 2 in the row and thus only 33 feet from the ditch.

The method of watering was always the same for both. When the trees were young, a single furrow on each side furnished the water until they were about six year old, when another furrow was added to each side. The water was turned into these and allowed to run until it was thought sufficient had been given them. The rows were about 575 feet long and required from three to six hours for the water to run through them. After it had reached the bottom, it was allowed to run from three to five hours; the entire time consumed in watering being eight to ten hours.

If the water was always confined to the furrows the Elberta would have received but little more than the King’s Prize, but it is highly probable that the water was constantly breaking over at the head ditch and as a result a greater area was saturated and remained so as the cultivations were given as soon as possible after watering. Thus there must have been an inverted V shaped section of soil on each side of the tree rows or under each irrigation furrow that was saturated while the soil between these areas, a distance of six to eight feet was relatively dry. This would be true of all of the orchard excepting the areas at the ends which were flooded more or less at each watering—the upper end from the breaking over of the water from the head ditch—the lower end from the waste water backing up and flooding over more or less.
Thus it is probable that the trees near the ends had root systems, more or less that of the Elberta, while those in the center were more or less like that of the King's Prize. For as long as there is sufficient moisture in the first few feet of soil to supply the needs of a plant it seems that there is a tendency for the roots to develop near the surface. But when only a small area of surface soil abounds in moisture the roots are compelled to penetrate more deeply.

This emphasizes the necessity of studying the method of irrigating and adapting it to the soil conditions and texture.

**Winter Bartlett Pear.**

This tree was healthy and about 11 feet in height and was numbered thirteen in the row of mixed varieties. The trees on

![Vertical Projection](image1)

![Horizontal Projection](image2)

**Fig. 3—Bartlett Pear root system.**
either side were also Winter Bartletts, the one on the west was healthy, while the one on the east was decidedly off color, and was classed as sick. All of the trees northward were dead and just south of this row was a thrifty lucern patch which replaced the vineyard removed in 1908. As before indicated the trench was dug on the east side of this tree, and the soil was moist below the first spading.

The small feeding roots were very numerous and long and stringlike. The largest main roots are distinctly surface feeders while the smaller ones and those of uniform size generally went downward.

It will be seen by studying the accompanying graph that the total spread was over 20 feet and the ultimate depth about 9 feet three inches. The root system itself was distinctly lopsided, the southeastern area being entered by but two roots both of which

![Horizontal Projection](image1.png)

![Vertical Projection](image2.png)

**Fig. 4—Jonathan Apple root system.**
went almost straight down to and below the water level, which on September 28, 1910, stood at 8 feet three inches depth from the surface.

It will be noticed that six roots of the twelve reaching a depth of 6.5 feet, were dead at or just below that point, while another one was dead below 7.5 feet. The portions of the others going below 6.5 feet were very small and could easily have grown in one or at the most two seasons.

From the condition of the soil around the tree we feel safe in saying that it is probable that had peach or apricot trees been growing in this area, they would have died out. It will be noticed here that the downward trend of the roots was limited by the position of the irrigating furrows.

Jonathan Apple.

This tree was located on Plat D block three, lot five, and was about number 12 in the row. All of the trees immediately around it were in a healthy condition. It was planted in 1904.

The soil for the first three feet was of a clayey nature, not moist enough for a plant to live in, below it was a loose sand which was quite moist. Water stood at a depth of ten feet.

The root system presented a sharp contrast to those of the peaches having relatively small main roots, though many more of them. These rapidly divided. There were innumerable small fibrous roots, many more than there were on the Pear roots.

The same one sided development of the system was found here as in the case of the Elberta and like it there was scarcely a root in the trench when it was dug. Looked at as a whole the spread north and south was a little over 15.5 feet and to the east slightly more than 10 feet with not more than three or four feet to the west.

In the matter of depth they had already reached water level at 10 feet. The tree was about 10 feet high and had a spread of not over eight feet.

Grape Vine.

This was a Thompson Seedless vine that was dug out of D 1-3-1 row one, number 8, counting from the west. The root was six years from setting out and was probably a year old when planted.
The trench was dug on the south side, October 6. The soil was exceedingly dry—so dry and hard that it was impossible to preserve the fine network of small roots that practically filled the first four feet of soil. These rootlets were also found just beneath the surface. The condition of the soil was also responsible for the breaking of many of the roots that we were following and for that reason the results were not as satisfactory as could be desired.

The accompanying graph however shows a total spread of 10 feet with the probabilities that it extended two or three feet farther. It also shows a total depth for a single root of 9 feet 2 inches. At that depth there were numerous rootlets in fact almost a mat and these unquestionably came from other roots so that it is probable that if we could have traced the other four roots, they would have reached at least that depth.

In the digging out of these roots we were continually encountering roots that came from adjacent vines and this coupled with the spread already mentioned, indicates that the vines should be planted farther than 7 x 7 feet as they are at present. If they were 8 x 9 feet or 10 x 8 feet, it would probably be better. This of course will vary with the variety and the fertility of the soil, the more vigorous ones requiring more space and those of weaker habit, less.
FRUIT TREE ROOT SYSTEMS

SUMMARY.

Fruit trees may ordinarily be expected to send their roots deeply into the ground if the water supply is not too plentiful especially near the surface and ground water level is not too close. The depth as indicated in these few examples, may be somewhere near the height of the tree.

The method and amount of watering will alter the general shape of the roots system and make it essentially a deep rooted tree or a shallow rooted one. It may also seem that if care is exercised in properly spreading the roots at planting time, the root development will be more nearly symmetrical.

If the raise in water level is not too great it would seem that trees might be saved by judicious applications of irrigation water, the amount being enough to keep the surface moist, without adding to the supply below.