STUDIES ON LATERAL MOVEMENT OF PHOSPHORUS 32 IN PEPPERMINT

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Auchter (1) was the first to show that very little lateral movement of nutrient elements occurred in certain plants. The work of Caldwell (3) and McAmurtrey (7) also indicated a lack of lateral movement of mineral elements in the test plants used. From these studies, it seems that there is a lack of lateral movement of mineral nutrients in some plants.

It was decided to test this idea using the radioactive element P32, in peppermint (Mentha piperita L.) plants.

The purpose of this study was to investigate, using a split root technique and P32, the type of movement that occurs when a peppermint plant is fed through a specific portion of its root system.

**Materials and Methods**

The square stem of peppermint, when allowed to root, characteristically develops roots at each of the four corners of the stem allowing a rather ideal separation of the four main vascular bundles.

Peppermint stock plants were grown in the greenhouse under a short day photoperiod to maintain the plants in a vegetative condition. Cuttings were made from the stock plants at various times as the need arose. After rooting, the cuttings were then placed on full strength nutrient solution (5) until they were used. Each plant used contained at least seven pairs of mature leaves.

In the method used to feed just half the root system, the basal portion of the stem was slit longitudinally 3 to 3½ in with a razor blade. This di-

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**Fig. 1.** Diagram of a peppermint plant showing the symbols designating the different areas as related to the radioautographs which were used in studying the lateral movement of phosphorus.

**Fig. 2.** Diagram of a peppermint plant showing results of one-half feeding techniques as seen in figure 3. Leaves III, V, etc. in figure 3 are above I. Leaves IV, VI, etc. in figure 3 are above II.
vided the root system into two equal parts. When just a quarter of the plant was to be fed, one of the half sections was then split in half.

The feeding apparatus consisted of plastic Crown Freez-Tainers. These containers held 405 ml of nutrient solution up to the fill line. Three containers were lined up next to each other and held in place by means of Scotch tape. Three rows of such containers were used per feeding apparatus making a total of nine containers. Bamboo stakes supported the plants.

Plants were placed in the containers in such a manner that one-half or one-fourth of the roots, depending upon the type of split, were placed in center container. The remaining roots of the plant would then be placed in one of the two adjacent containers. The containers were large enough to allow four plants to be placed next to each other which gives a total of eight plants per three containers.

After the plants were placed in the containers, the containers were covered with aluminum foil. One week was allowed to pass before feeding the plants radioactive phosphorus. This was to allow healing of the wound caused by the splitting and also to allow new roots to form.

At the time of feeding, the containers were filled to the fill line indicated on the containers and 50 ml of nutrient solution was pipetted out of the center container. This was immediately replaced with 50 ml of radioactive phosphorus at a strength of 5.5 μc/ml. Four plants were harvested at 6, 24, 48, 96, and 144 hours after applying P32. Each harvest period represented four plants which were fed P32 through one half or one fourth of its root system.

The method of pressing and drying the plants was as follows. The plants were dried in a herbarium press at 75° C for 24 hours. The plants were then mounted with Duco cement on 14 by 17 in cardboard. The radioautographs were made with no-screen X-ray film by placing the film in direct contact with the plant material in a weighted X-ray exposure holder. After exposure the films were developed in the normal manner.

**RESULTS**

To be able to interpret the results of this study, one must first examine figure 1 and become acquainted with the marking procedure of the leaf pairs and the individual leaves. Leaves of peppermint have an opposite decussate phylotaxis with a phylotactic fraction of one-third.

Leaf pairs are designated by Roman numerals. The lowest pair of leaves being pair I, the next pair of leaves pair II, and so forth up to the stem. The right leaf of a pair of leaves as seen when one is observing a mint plant directly in front of him is designated by a prime (') sign. The individual leaves of a pair of leaves are further subdivided into sections A and B, section A being the farthest half of an individual leaf as one is observing the plant when it is directly in front of him. Section B then is the closest half of the individual leaf.

Once the plants are pressed, the leaves all seem in the same plane but this is not how they grow. In both the radioautographs the odd numbered pairs of leaves (pairs I, III, V, etc.) were growing as they appear in the radioautographs. The even numbered pairs of leaves (pairs II, IV, VI, etc.) were pressed in such a way that they appear 90° out of their normal position. In all cases the leaves designated by the prime (') sign (right half) will appear to the right in the radioautographs. The other half of the pair therefore appears to the left in the radioautographs.

The results of the uptake by half the root system are shown schematically in figure 2. Figure 3 shows quite clearly that in feeding radioactive phosphorus to just half the plant's root system that the radioactive phosphorus remained essentially in just half of the plant (compare the A' and B' sections of the odd numbered leaves with the A and B sections). In every case where the P32 was fed to half the roots, there appears to be very little lateral movement to the other half of the plant.

![Radioautograph showing distribution of phosphorus 32 in the aerial portion of the peppermint plant after feeding one-half of its roots system for a period of 144 hours.](image-url)
It is also interesting to note that in the even numbered pairs of leaves (II, IV, etc.) the radioactive phosphorus is distributed in just half the individual leaf (B' section of leaves II, IV, etc.). There is a slight movement from the B' section to the A' section in the even numbered leaves though it appears that this movement from one section of the leaf to the other section of the leaf is quite slow since after 144 hours feeding an even distribution of radioactive phosphorus is not noticeable in the entire leaf.

These results show that when P32 is fed to half of the root system of a peppermint plant that the phosphorus shows very little lateral movement to the other half of the plant.

The results of the uptake by one-fourth of the root system are shown schematically in figure 4. These results shown in figure 5 agree quite nicely with the results of the one-half root feeding technique. In feeding just one of the four main vascular bundles of the peppermint plant the radioactive phosphorus accumulates in either the A section of the leaf or the B section of the leaf depending upon which one of the vascular bundles is fed. In every case, if the radioactive phosphorus appears in the A section of the odd numbered leaves, it then appears in the B section of the even numbered leaves. The reverse of this pattern is true also. Here, too, there appears to be movement of the radioactive phosphorus from one section of a leaf to the other section. The movement here is quite slow also, as can be seen in figure 5.

These results also indicate that there is very little lateral movement of the phosphorus. These results show more clearly that the individual vascular bundles of the mint plant feed certain leaves and even a certain portion of the individual leaf involved.

**Discussion**

The peppermint plant was chosen for this lateral movement study because of its anatomical and morphological characteristics. *Mentha piperita* L. contains its complex vascular tissue in the four corners of the stem as shown by Chamberlin (4). She pointed out that the vascular tissues in the four corners are connected to one another by continuous interfascicular cambium which produces connecting xylem and phloem tissue. Thus, the tissues in peppermint are present in which lateral transport of minerals may take place.

The results noted with peppermint agree with the previous work done by Auchter (1), Bodenberg (2), MacDaniels and Curtis (6), Caldwell (3), and Murntrey (7). The results show that when P32 is taken up by a specific portion of roots it is translo-
uated to a specific portion of the plant involved. This is shown in the radioautographs presented. The radioautographs show very little movement of the \( ^{32}P \) from one side of the peppermint plant to the other side of the plant over a period of 144 hours. The relationship between the roots feeding a specific portion of the plant is brought out even more strongly by noting the even numbered leaves of the one-half feeding technique and the leaves containing the radioactive phosphorus in the one-quarter feeding technique. In these instances the radioactive phosphorus initially was distributed in just half of an individual leaf, though some movement did occur after the initial distribution. These results agree with the work of McMurtrey (7). This, though, is not the case in strawberries as reported by White (9), and the work of Ririe and Toth (8) with tomatoes.

**Summary**

Radioautographic techniques were used to follow the feeding of radioactive phosphorus in peppermint plants. The radioactive phosphorus was fed in such a manner to feed one-half and one-quarter of the plant's roots at a time. This type of feeding technique enables one to follow lateral movement of the radioactive tracer that is fed to the plants.

In all cases it appears quite clearly that very little lateral movement of the radioactive phosphorus took place up to 144 hours.

**Literature Cited**