ROOT-FEEDING IN A GRASSLAND SOIL: OBSERVATIONS FROM A RHIZOTRON

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SUMMARY

The efficacy of a simple rhizotron as a means of studying root-feeding in a grassland soil was demonstrated. Earthworms and slugs were the most important herbivores found. Diplura, Nematoda, Enchytracidae, Elateridae and Collembola were less important.

INTRODUCTION

Rhizotrons have long been used for the agronomic study of roots, but seldom utilised to study root-feeding by invertebrates. The first rhizotron was built in the late 1920's at East Malling (Rogers 1939) and although there has been a rhizotron operating there ever since, little information on root-feeding has been collected. The biology of *Trichodorus viruliferus* on apple trees was studied (Pitcher and Flegg 1965; Pitcher 1967); Harding (1968) reported briefly on the soil fauna; and Atkinson and Wilson (1979) commented on the role of invertebrates in root-soil contact. Other than these workers at East Malling, root feeding on cotton has been simulated by clipping with scissors in a rhizotron in the USA (Stansell *et al* 1974). In an East African rhizotron Huxley and Turk (1975) used an insecticide to stop chafer larvae damaging coffee roots.

It was thought that a rhizotron might help to understand root/animal interactions for two reasons; firstly to see how invertebrates behave in the soil, particularly as this may affect pest status and to determine the density of a particular species needed to affect foliage production. Secondly, a direct study of how root systems resistant or tolerant of pest attack are affected by soil animals may provide insight into how plant breeding programmes for pest tolerance could be better directed. An extension of both these aspects would be to use a rhizotron to study the way insecticides affect soil animals, particularly pest insects and earthworms.

As an introduction to research of this type, it was necessary to use a rhizotron to establish methods of doing the research and identify potential difficulties before commencing a major project. This paper briefly describes a small rhizotron that was built in an amenity grassland at Bangor, North Wales in 1983, to evaluate the method in relation to the points raised above.

METHOD

The rhizotron was built at the top of a slight slope in an amenity grassland dominated by ryegrass (*Lolium perenne*), Yorkshire fog (*Holcus lanatus*), white clover (*Trifolium repens*) and broadleaf weeds. The grassland was mown infrequently and was not fertilized.

The rhizotron (Fig. 1) was built with a concrete floor 165 cm below soil level with a drain to carry away water. The walls were made of concrete blocks for the first 80 cm and then of 12 mm plate glass to 40 cm above soil level. The roof was made of 10 mm plywood covered in tar paper. It sloped towards the west and had a door in the eastern side. The rhizotron was 2 m square. The installation was supported by metal uprights. Full dimensions and construction details are given by Carpenter *et al* (1985).

After the structure was complete the soil was placed back around the rhizotron, and rammed firmly into place. Ryegrass, white clover and sweet vernal (*Anthoxanthum odoratum*) that had been grown in hygiene trays were planted over the disturbed soil and then everything was left for 3 months to stabilise.

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Proc. 39th N.Z. Weed and Pest Control Conf.

Fig. 1: The Treborth Rhizotron. Scale 1 cm = 40 cm, g = glass, p = plywood roof, w = concrete block wall, d = door. A. The north elevation. B. The east elevation.

From August 1983, a variety of observations were made at least once a week. Roots were traced onto acetate sheets, using a different coloured ink each week. Any roots that had died or disappeared were noted. After 15-20 weeks, the acetate sheets were taken back to the laboratory and the length of root growing each week was measured to the nearest cm with a map measurer. At the beginning of each visit the depth distribution and activity of any invertebrates was recorded. Observations on invertebrate activity were made with a 10 x hand lens. All observations on the invertebrates were made as quickly as possible after entering the rhizotron to minimise the effect of light on their activities. For various periods during the study, root tips of known age were marked on the glass with permanent ink and they were then checked each day to record invertebrate damage and activity and the general condition of the tip.

TABLE 1: Food types taken by invertebrates as observed from a rhizotron.

Taxon (1), (2)	Food type				
	Mature root	Root tip	Root hairs/hyphae	Live animals	Dead material (3)
Nematoda		+	+		
earthworms	+	+	+		+
Enchytraeidae		+	+		+
slugs	+	+	+		
Symphyla			+		
Diplura	+	+		+	+
Collembola		+	+		+
beetle larvae				+	+

Notes

- (1) The following were never observed feeding: millipedes, centipedes, beetle (adults), Diptera, mites, spiders, isopods.
- (2) Many taxa could not be identified to even family level.
- (3) This category includes both animal and plant material. Many taxa feeding on it may have been microbial feeders.

TABLE 2: Longevity and fate of root tips as observed from a rhizotron.

Number of root tips observed	287
Mean length	2.7 cm
Percentage damaged by invertebrate feeding	50.9
Mean longevity of root tips	14.6 days (range 3-46)

RESULTS

A wide range of invertebrates were observed eating roots; nematodes, earthworms, enchytraeids, Diplura, Collembola, insect larvae and slugs. Many of the taxa that ate roots also took other food types. In Table 1 these observations are summarised into three classes of root material; root tips, root hairs/mycorrhizal hyphae and mature roots. The most notable feature of these observations is the generalist nature of food selection by the soil invertebrates studied.

With the exception of enchytraeids and nematodes all the invertebrates listed in Table 1 utilised earthworm burrows to move about in the soil. Thus, root-feeders were concentrated in burrows where food selection was restricted by what was available. Proportionately more root tips were found in earthworm burrows than outside (Carpenter 1985).

Detailed observations on the longevity and fate of root tips are summarised in Tables 2 and 3. From Table 2 it can be seen that during the periods of study half the root tips observed were damaged by root-feeding invertebrates. The mean longevity of root tips was 14.6 days, ranging from 3 to 46 days. However, there were always some root tips left alive at the end of a period of detailed observation. If these had been followed to death the mean longevity may have increased.

The relative importance of the root-feeding invertebrates observed during this study is shown in Table 3. The most important herbivores were worms. Less important were slugs, Collembola and Enchytraeidae. Least important apparently were nematodes and Diplura, although nematodes were not easily visible.

TABLE 3: Percentage of damage to root tips and root hairs/hyphae caused by various taxa.

Taxon	Percentage
earthworms	25
slugs	6.2
Collembola	3.1
Enchytraeidae	2.6
nematodes	0.5
Diplura	0.5
unaccounted for damage	62.1*

*The cause of damage could not be assigned by direct observation.

DISCUSSION

The simple rhizotron used for this study showed that a rhizotron can produce useful data on root-feeding in a grassland. One of the major difficulties, however, was obtaining quantitative data on root production, root death, amount of root consumed by the various invertebrates and the density of the invertebrates. Quantitative estimates depend on assumptions such as the depth of the field of view through the glass, the attractiveness or repulsiveness of the glass plane to roots and invertebrates, and information on root length/density relationships. Modification of the design so that parts of the windows are removable for access to both animals (to allow specific identification) and to roots (to allow length/depth/density data to be collected) would increase its utility. It is likely that mathematical modelling of root dynamics would be needed to produce quantitative data.

The difficulties of identifying invertebrates through the glass were not overcome. Some fauna observed from the rhizotron were not found in a parallel coring/heat extraction study, notably the Diplura and slugs (Carpenter 1985). Conversely mites were seldom observed but were common in the coring study. Nematodes were also difficult to see. As a result the effects of mites and, more importantly, nematodes were underestimated.

Invertebrate feeding was the major, if not the only, cause of death of root tips. The dynamics of the root tips, physiologically the most active part of the root system, was closely related to invertebrate activity. Tips more frequently occurred in earthworm burrows where their longevity was dependent on how soon they were found and consumed.

The root-feeding observed in this grassland was entirely by 'innocuous' animals. Presumably such background levels of herbivory occur in all temperate grasslands, particularly from earthworms and slugs. Any pest must have an additive effect. Comparable data from a grassland with a 'pest complex' would be informative.

This study has provided a basis for more applied research relating to insect control and plant production research. Experiments have recently begun, using this rhizotron, to gather more quantitative data on root production and to investigate the effects and interactions of insecticide and fertiliser granules and insecticidal baits with the soil fauna and plant roots. There is also a possibility of using this method to gain an understanding of the mechanisms of plant tolerance or resistance to insects. However, the usefulness of the technique for studying pest status and threshold density remains unknown.

ACKNOWLEDGEMENTS

This research was generously supported by the National Research Advisory Council. I am grateful to my supervisors, Dr J.M. Cherrett and Dr J.B. Ford for their help. Without the skills of Merion Thomas and Edward Evans the rhizotron would never have been built.

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