TRANSLOCATION OF BENOMYL IN ELM (*ULMUS AMERICANA* L.)

VI. EFFECTS OF SOIL APPLICATIONS ON ROOT UPTAKE AND DISTRIBUTION IN MATURE TREES

by

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OTTAWA, ONTARIO

Information Report CC-X-54

October, 1975

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RÉSUMÉ

L'absorption et le cheminement du benomyl et du chlorure de MBC dans les racines des gros ormes ont été étudiés sur le terrain par des techniques d'imbibition, de rigolage et d'injection sous pression. Des tubes perforés en plastique avec sorties extérieures ont été employés pour l'imbibition et le rigolage afin de maintenir un systéme permanent d'irrigation souterraine permettant l'application annuelle de fertilisants et de pesticides. Aucune des méthodes étudiées n'a donné une absorption satisfaisante de fongicides par les racines. L'absorption et la distribution ont été faibles et irréguliéres au cours de trois années, et une grande partie des fongicides sont demeurés dans le sol où ils se sont lentement dégradés. On laisse entendre que les applications de benomyl dans le sol ne constitueraient pas une méthode efficace ni acceptable du point de vue écologique et économique, contre la maladie hollandaise des gros ormes.

INTRODUCTION

Several investigators have reported control of Dutch elm disease in affected trees by soil application of benomyl (Biehn and Dimond, 1971; Smalley, 1971). In some cases, very large quantities of benomyl (600 lbs/acre) have been used and this amount could be sufficient to cause undue contamination to the edaphic environment since benomyl has been reported to be toxic to earthworms (Stringer and Wright, 1973 and Prasad and Moody, 1974). Also, Hock et al (1970) found that effectiveness of the treatments depends upon the soil texture and structure, and therefore caution has to be taken before a general recommendation can be made for soil applications. Even though it has been recognised that systemicity of benomyl and its related salts is greater by roots than by foliage (Kondo, 1972; Prasad and Travnick, 1973), massive application to soil is expensive and detrimental to the ecosystem.

The purpose of this investigation was to design an efficient, relatively inexpensive and safer technique for application of benomyl to soils and the present report describes some aspects of drenching and pressurized soil-injection as suitable methods for pesticide application to soils sustaining elm plantations.

MATERIALS AND METHODS

(i) Elm Trees

Fifty mature elm trees of average (dbh - 7") were selected at two sites near Ottawa, at Shirley's Bay and Champlain Bridge. The soil was relatively free from large rocks and consisted of light loam with a few inches of organic matter. Trees were tested for the absence of the DED and only healthy, vigorously growing and uniform individuals were finally marked and tagged.

(ii) Chemical Compounds

MBC-chloride prepared from benomyl (Benlate 50% WP. DuPont Canada) was used for soil incorporation. MBC-chloride was prepared according to procedures of Gregory, Jones and McWain (1973). A suitable concentration (1000 ppm) was prepared and stock solutions were stored in plastic containers. For some trees, a suspension of benomyl (5000 ppm and 5 lb/tree) were also tried.

(iii) Method of Application

There were three modes of treatment:

(A) Soil drenching with a perforated circular plastic tubing,

(B) Soil drenching with a perforated rectangular tubing, and

(C) Pressurized soil-injection.

A. Soil Drenching with Perforated Circular Tubing Method:

Benomyl suspension and solutions of MBC-Cl were dispersed around the roots with the aid of perforated plastic tubes laid beneath the surface of the soil in three different layouts as seen in Figures 1 and 2.

1. Small double circle - three trees were fitted with two concentric rings of 3 and 4 ft. diameter.
2. Large double circle - Three trees were fitted with two rings of 9 and 11 feet diameters, respectively, and
3. Small circle and spokes - Three trees were fitted with a circle to which 4 spoke tubes (8 ft. long) following the direction of four main roots were attached (Fig. 2).

These systems were constructed as a permanent arrangement around the base of a tree, buried under the surface (6") with outlets (about 2 feet long) for repeated treatments protruding from the ground. In all trees, plastic tubing of one inch inside diameter was used, connected with plastic "T" or elbow joints. On the bottom side 1/8 inch holes were drilled in each tube, spaced 6 inches apart to facilitate drainage. The tubes were laid on sand and gravel so that drainage of the pesticide solution was rapid. Care was also taken to level the tube uniformly for equal distribution of solutions around the tree.

The treatment itself, consisting of 10 litres of 1000 ppm concentration of MBC-chloride, was applied twice during May at two week intervals. The suspension of benomyl (10 litres, 5000 ppm) was applied in the same way and later flushed with water to ensure all residues were effectively washed down through the perforations. These systems were used for three years (1972, 73, 74), and applications were made each year.

B. Soil Drenching with Rectangular Tubing Method:

Because roots from large trees tended to be deep-seated a different approach, using trenching was attempted. A special "Ditch digger" machine was used to cut trenches 4 inches wide, 6 inches deep and 16 feet long in a rectangle around each tree. One inch thick layer of sand was distributed into each trench together with 2 lbs of 10-15-17 (NPK) fertilizer per tree so as to stimulate new root growth (Fig. 3a, b). Then, a plastic tube (1" i.d.), perforated in the bottom with 1/8 inch holes spaced 6 inches apart, was levelled into the trenches. The trench was finally covered with a fill and the sod was replaced on the surface. Again, tubes, 2 feet long, connected by plastic elbows to the tubes in trenches, were left protruding from the ground for pouring of the pesticide solution (Fig. 4).

Ten trees were treated twice with 10 litres of MBC-chloride (1000 ppm concentration) per tree. Two trees were used as controls using water as treatment. The solution was applied twice in June, at two week intervals and this system was used only for two years (1973, 74).

C. Pressurized Soil-Injection

Arborists have long employed pressurized soil-injection of fertilizer for correction of nutritional deficiencies in trees and the same system was used for suppression of the DED with benomyl. Fifteen trees of an average d.b.h. 7" were selected at Shirley's Bay. The treatment was applied at the beginning of June, with 20 litres of MBC-chloride (1000 ppm) or equivalent to 80g benomyl per tree in the first year. However, in the second year the dosage was raised to 5 lbs of benomyl (in 15 gallons of water) per tree.

For this purpose a John Bean sprayer of 20 gallon capacity was used. This was equipped with a 2.5 HP Briggs and Stratton gas engine and pump with pressure gauge (400 p.s.i.), a high pressure hose (25 ft.) and an injection gun. The gun had a 2 foot long pipe of ¼ inch inside diameter with a tapered end, which was inserted into the ground to a depth of ca 6 inches and the flow of liquid under pressure was controlled by a triggered valve. Applications were made with this pressurized gun at intervals of 2 ft. around each tree, starting from the base and finishing up to the dripline of the crown. Usually injections were made all across the ground covering much of the root system proliferating in all directions (Fig. 5).

From all these treatments, samples of leaves, twigs and cores of the trunk (at breast height) were collected at 15, 30, 60 and 90 day intervals and bioassayed for fungitoxicity by a procedure as outlined by Prasad and Travnick (1973). Thin-layer chromatography (TLC) of treated soils for determination of the fate of the fungitoxic compounds was performed according to a standard technique described by Prasad and Moody (1974).

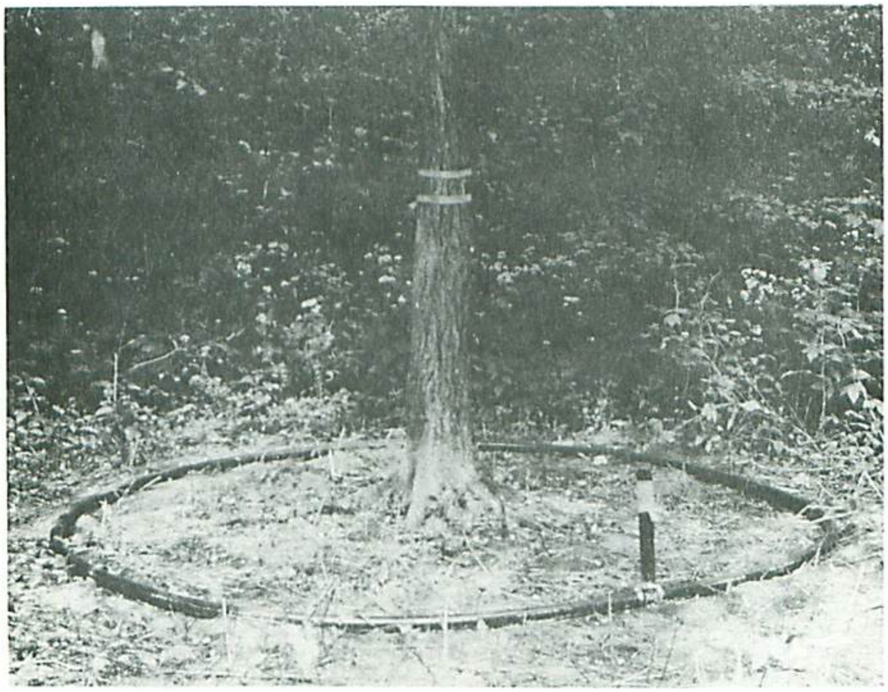

Fig. 1. Method of application of benomyl to soil through plastic tube. The large circle of the tube was buried underground and benomyl poured through the outlet. Picture shows one circle only.

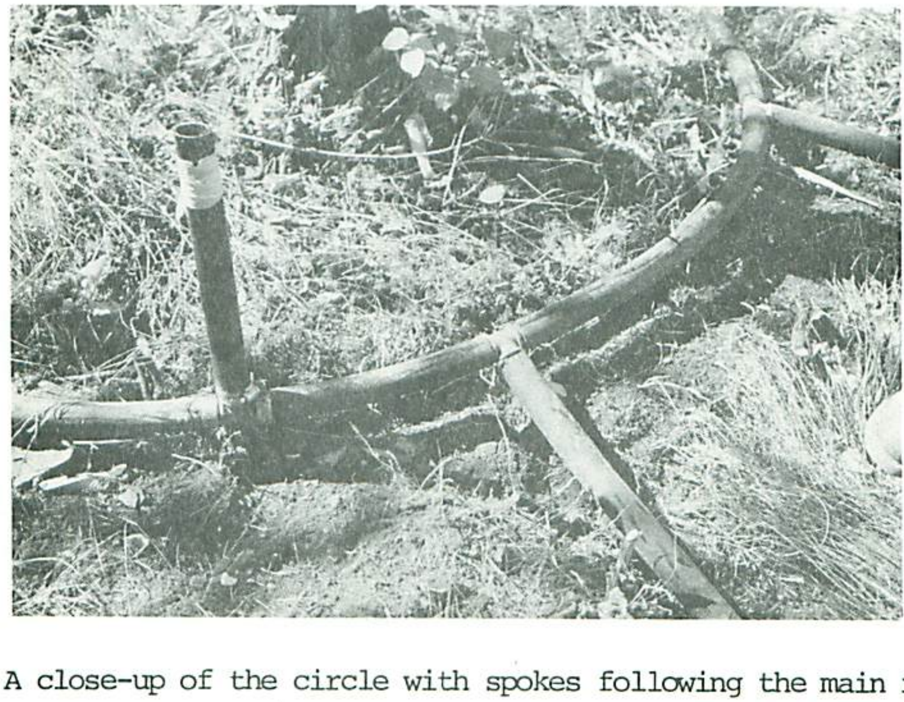

Fig. 2. A close-up of the circle with spokes following the main roots.

(a) (b)

Fig. 3. (a) Method of application of benomyl to soil for DED control. "Ditch digger" machine cutting soil trenches.

(b) A view of the trench before placement of the plastic tubes.

RESULTS

A. Circular Tubing Method

The uptake of the fungicide from the drenching experiments was monitored for three years (1972, 73, 74) and is summarized in Figs. 6, 7 & 8. Clearly, the uptake and distribution patterns are erratic and irregular from year to year. During the first year of treatment (1972) hardly any material moved up to the foliage and whatever translocated through the trunk (core) did not exhibit any positive trends. The three methods of treatment (small circle, large circle and circle with spokes) did not have any significant effect on uptake and distribution pattern.

On the other hand, the uptake and distribution from 1973 applications by all three methods was greater than 1972 treatments. Most uptake took place by the small circle and circle and spoke attachment methods. The double circle method was not so effective. All parts of the tree showed fungitoxicity and the core samples contained the most. But, this trend was again reversed during the 1973 treatments. Here, once again, the uptake resembled the 1972 experiments by all three methods of treatments. Therefore, the pattern of uptake and translocation of benomyl is not consistent over a period of three years and caution should be used in using these methods for disease control.

B. Rectangular Tubing Method

The data from these experiments were compiled during 1973 and 1974. From Fig. 9 it is evident that there was no detectable uptake during the first year of treatment while there was rather insignificant uptake and movement during the next year. Such low concentrations of fungitoxic materials in the tree would not be inhibitory to the DED and

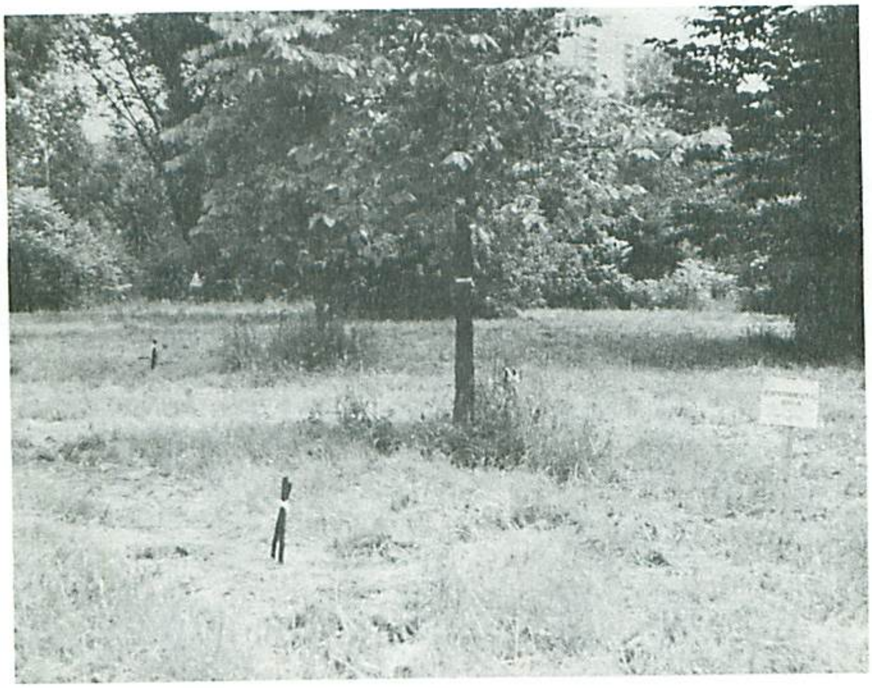

Fig. 4. Method of application of benomyl to soil; the trenches were covered with soil after placement of tubing. Benomyl was poured through two outlets as shown in the photo.

Fig. 5. Soil injection of benomyl under high pressure.

considering the heavy application to soils over a period of 2 years, it is questionable whether trenching would be of any practical value for control operations.

C. Soil Injection

Two years' data (1973, 1975) from soil injection experiments are presented in Fig. 10. Clearly, here again, there is no significant uptake and distribution into the tree system and therefore this method of treatment does not appear to be suitable for DED control in large trees.

Persistence and Fate of Benomyl in Soil

Because the uptake was poor and erratic from the soil applications, the fate of the applied materials was investigated. Samples of soil were taken from different sites of treatment and bioassayed for fungitoxicity. Appropriate control samples were bioassayed at the same time. From Table I, it can be seen that there was appreciable quantities of MBC-Cl present in all these soils 5 months after treatment. The maximum amount found was in the circular tubing method. Thus, it appears that either this compound was not readily available to the roots or was being degraded into other products which were not being absorbed by the roots. Consequently, some soil samples treated with benomyl were subjected to thin layer chromatography and inspection of Fig. 11 reveals that there was indeed a slow breakdown of benomyl into 21.7% MBC and 0.3% AB (aminobenzimidazole).

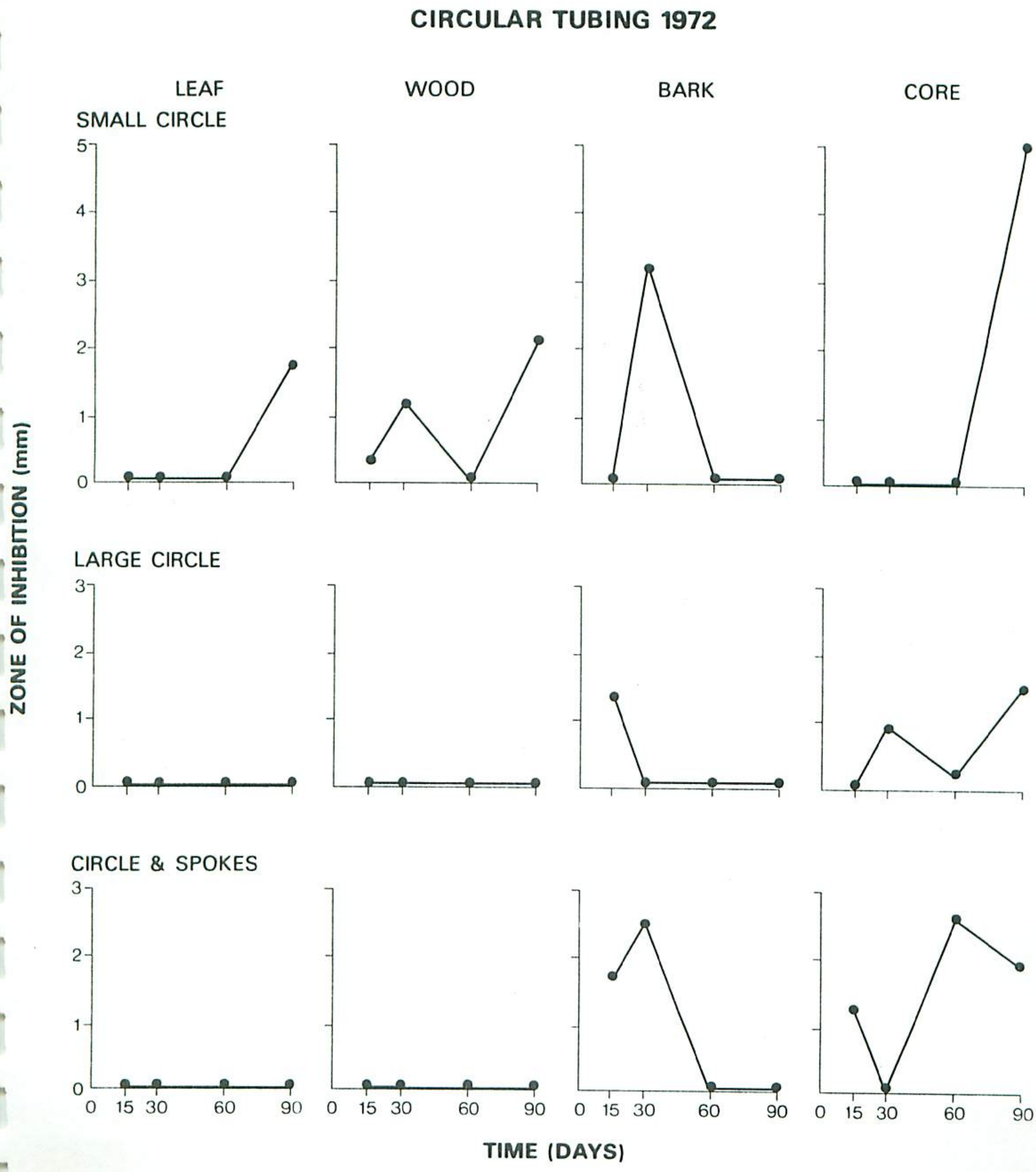

Fig. 6 Uptake and movement of benomyl in elm trees by application with (a) small circle, (b) large circle, and (c) circle and spokes methods.

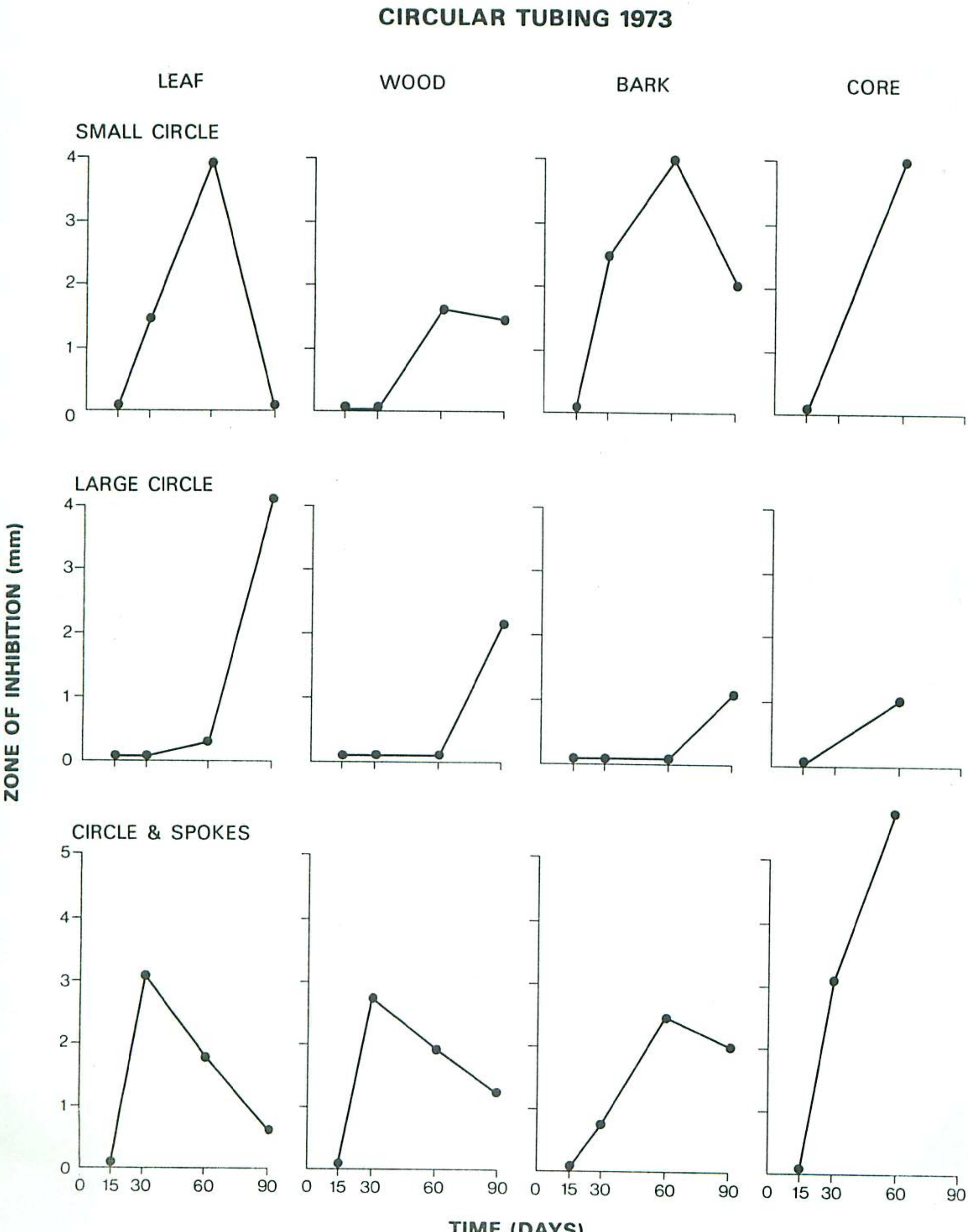

Fig. 7 Uptake and movement of benomyl in elm trees by application with (a) small circle, (b) large circle, and (c) circle and spokes method.

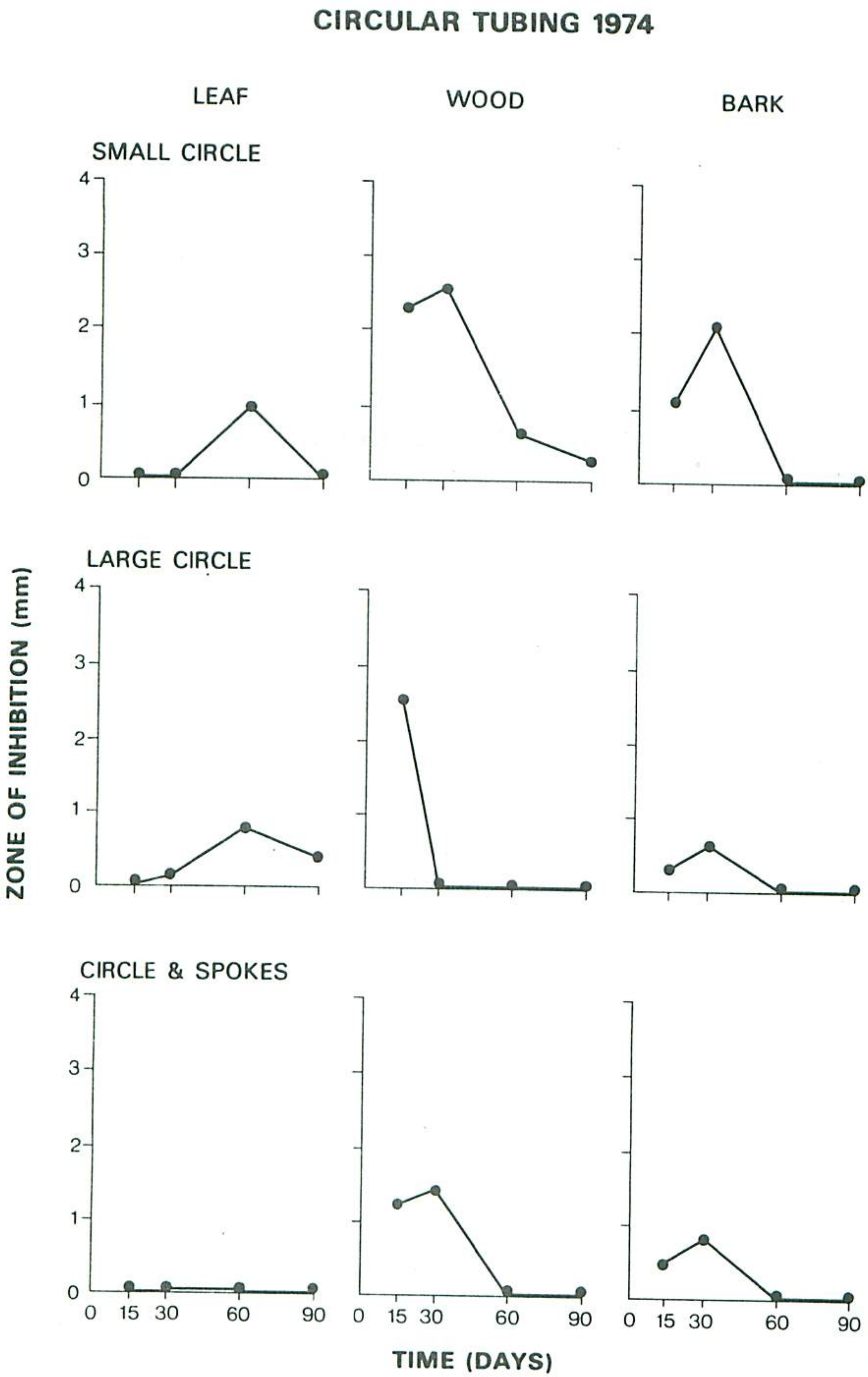

Fig. 8 Uptake and movement of benomyl in elm trees by application with (a) small circle, (b) large circle, and (c) circle and spokes method.

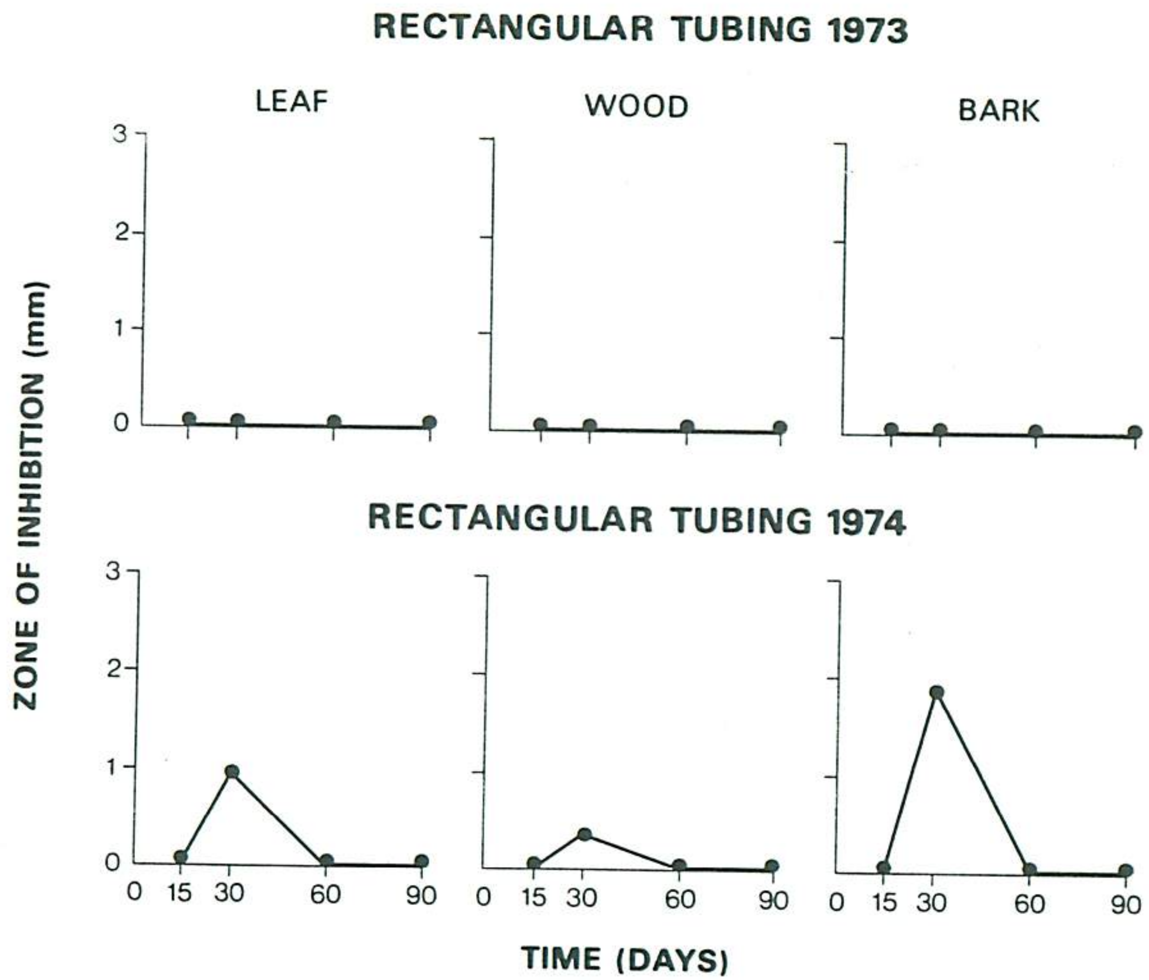

Fig. 9 Uptake and translocating of benomyl by elm trees following treatment with soil drenches (rectangular tubing method) during 1973 and 1974.

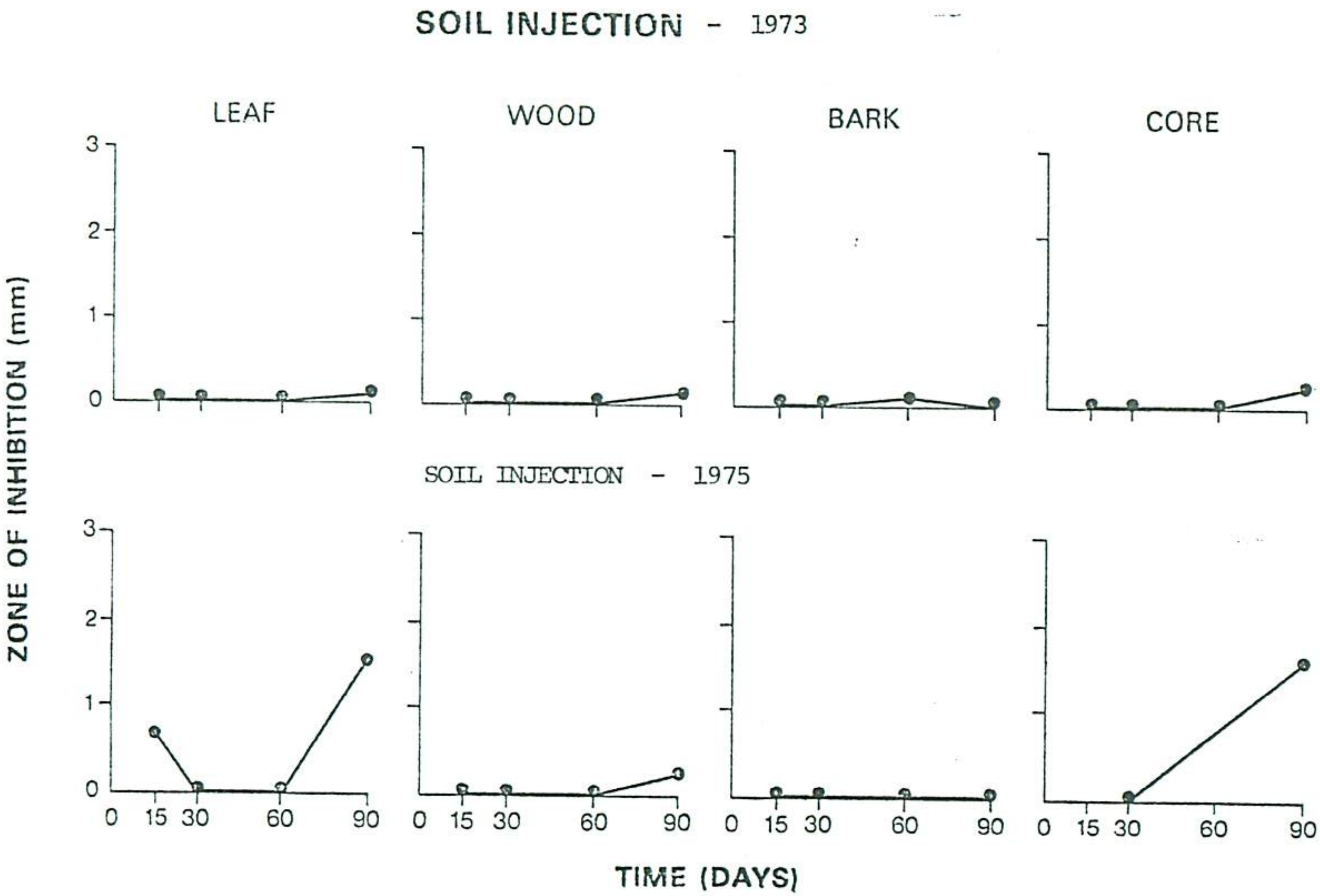

Fig. 10 Uptake of benomyl by elm tree roots following soil injection under pressure in 1973 and 1975.

TABLE I

PERSISTENCE OF MBC-CHLORIDE IN

FOREST SOILS 5 MONTHS AFTER TREATMENTS

Treatment		Persistence Level (Zone of Inhibition - mm)
A. Circular Tubing Method		
(i)	Small Circle Method	32
(ii)	Large Circle Method	44
(iii)	Circle & Spokes Method	44
B. Rectangular Tubing Method		18
C. Soil Injection Method		25
Control (Untreated) Soil		0

DISCUSSION

The data presented above suggest that soil applications of benomyl and MBC-chloride do not produce sufficient uptake by the roots of large and mature trees no matter whether the fungicides were supplied by the tubing methods or soil injection under pressure. What is more surprising is the fact that drenching by plastic tubing over a period of three years (1972-74) did not result in substantial quantities of benomyl moving up to the crown of the trees. Repeated applications over a period of three years should have built up a reservoir of concentration of benomyl in the rhizosphere region from where effective uptake by

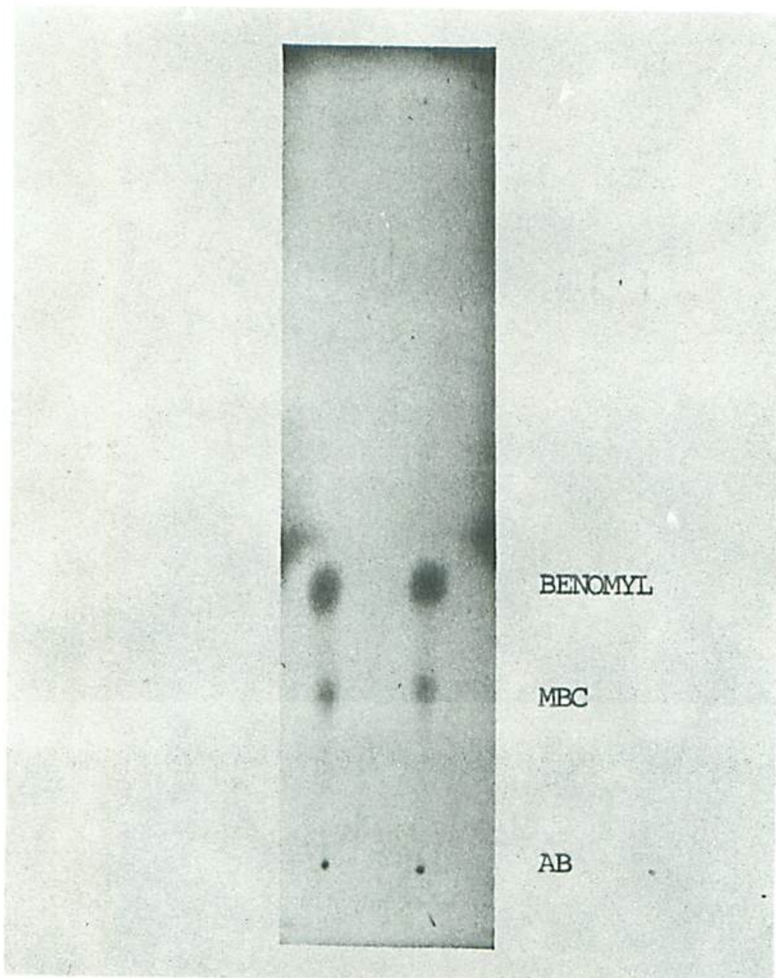

Fig. 11. Thin layer chromatography of benomyl from soil drenches showing degradation into Benomyl, MBC and AB.

actively growing roots should have taken place. But, according to Figs. 6, 7 & 8, the uptake was poor and erratic. A similar situation was noticed in the other experiments also. Very little uptake took place during two consecutive years of treatment.

There could be several reasons for the erratic behaviour of soil applications. Firstly, the mobility of the compounds is affected by the nature of the soil as has been pointed out by Hock et al (1972) and Pitblado and Edgington (1973). Many of the forest soils have high organic matter and this tends to adsorb the fungitoxic molecule, thus rendering it less available to the roots. Secondly, since most of the uptake takes place by root hairs and fine roots, it is possible that benomyl is not readily available to such roots. In large trees, it is somewhat difficult to trace the fine roots and it could be that benomyl got "fixed" (immobilized) in the organic soils at the point of application and did not move to the sites of absorption by the roots.

Another plausible explanation that could be advanced to account for the erratic uptake is the slow degradation of benomyl and MBC-chloride in the forest soils. Because of high organic matter, these soils must be rich in micro flora and fauna and, as such, they could rapidly decompose the fungicides. However, thin layer chromatographs from the treated soil shows a slow rate of degradation (only 22% in 5 months) and therefore this cannot account for poor uptake. It would appear that immobilization of the fungitoxicants by the forest soils is the key factor responsible for reduced uptake by roots. It also seems possible that considerable dilution and leaching of the applied dosage took place in soil water and hence the uptake was also adversely affected. Recent findings of Holmes

(1975) are of interest in this connection. Using 2.7 gm/cm of tree diameter of benomyl, he was able to inject sufficient quantities into the elm rhizosphere and adequate uptake was found to take place in the nursery trees. As a result, disease protection was also found to be satisfactory in these trees. However, high concentrations of benomyl are toxic to some ecosystems (earthworms) of the rhizosphere and great care should be taken against indiscriminate use of this pesticide for soil applications (Prasad and Moody, 1974).

SUMMARY AND CONCLUSIONS

The uptake and translocation of benomyl and MBC-chloride by roots of large elm trees, under field conditions, was investigated by soil drenching and pressurized-injection techniques. Perforated plastic tubings with external outlets were used to provide a permanent type of subirrigation system so that pesticides and fertilizers could be applied to each elm tree every year. Of all the methods tested, none of them provided satisfactory root uptake of the fungicides. The uptake and distribution was poor and erratic over a period of three years and much of the fungitoxic materials were immobilized in the soils and slowly degraded into other products. It is suggested that soil applications of benomyl would not provide an effective, ecologically acceptable and economical method of Dutch elm disease control in large elm trees.

ACKNOWLEDGEMENTS

The authors thank Mr R.P. Moody for technical assistance in field and laboratory, and Dr J.J. Fettes, Director, Chemical Control Research Institute, for provision of facilities. They are also grateful to National Capital Commission for providing help and trees for the project.

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