A METHOD FOR INTRODUCING WATER-SOLUBLE CHEMICALS INTO MATURE ELMS

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ABSTRACT

This paper describes a method of introducing water-soluble chemicals into young, greenhouse-grown elms through severed roots and an adaptation of the technique to mature, field-grown elms. Description of the apparatus, selection of roots and factors influencing uptake and distribution of aqueous solutions are included.

Within 48 hr of initiation of root injection with 0.5% acid fuchsin solution, the dye had stained the entire sapwood, much of the root system and almost all the leaves. Elms exhibiting symptoms of Dutch elm disease and healthy elms of comparable size took up similar amounts of dye solution.

This method shows a potential for introducing aqueous chemicals for chemotherapy, systemic chemical protection or fertilization of high-value elm trees.

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Cover photograph shows an overall setup for root injection into mature elms.

INTRODUCTION

In chemotherapeutic and systemic chemical protection of large trees, it is difficult to distribute the chemical uniformly. In Dutch elm disease, a systemic wilt, the pathogen *Ceratocystis ulmi* (Buism.) C. Moreau, is found in the host's vascular system; therefore, the chemical must be introduced uniformly into the vascular system without damaging the tree extensively.

Numerous methods have been tried to obtain adequate internal uptake and distribution of chemicals with minimum damage to the tree. Soil drenches have proved successful (Biehn and Dimond 1971; Smalley 1971); but the large amounts of chemicals required for large trees under field conditions make drenching ecologically undesirable. More direct approaches have been employed, such as trunk injections (Norris 1960; Gregory *et al.* 1971) and foliar and bark applications (Peterson and Edgington 1970; Hearn and Childs 1969). However, in most cases distribution of chemicals has been erratic and unpredictable. Furthermore, trunk injections can damage the tree considerably (Jorgensen 1966).

This paper describes a) an efficient method of introducing water-soluble chemicals directly into young, greenhouse-grown elms through severed roots and b) adaptation of the basic technique to mature, field-grown elms [*Ulmus americana* L.]. A patent application covering the injection techniques and principle described in this paper has been filed.

MATERIALS AND METHODS

The apparatus for root injection of water-soluble chemicals into 2-yr-old greenhouse-grown elms consists of a 2-liter (.43 gal) plastic reservoir, tygon tubing of various lengths and appropriate diameter, three-way connectors and a pressure rubber bulb (Fig. 1).

The modified root-injection apparatus for mature, field-grown elms consists of a 45-liter (9.9 gal) plastic reservoir (aspirator bottle), various lengths of 1.9-cm (3/4-in.) plastic tubing, three-way connectors, rubber adapters, clamps and a nitrogen-gas cylinder with a pressure regulator (Fig. 2).

In February, 1971, 2-yr-old greenhouse-grown elms which had been given a full dormancy period and flushed in January were injected with a 0.5% solution of acid fuchsin to determine uptake and distribution. In May and June, 1971, the same dye was used and the field root-injection apparatus was tested on elms up to 30.5 cm (12 in.) in diameter at breast height in the Tilley Lakes area north of Sault Ste. Marie.

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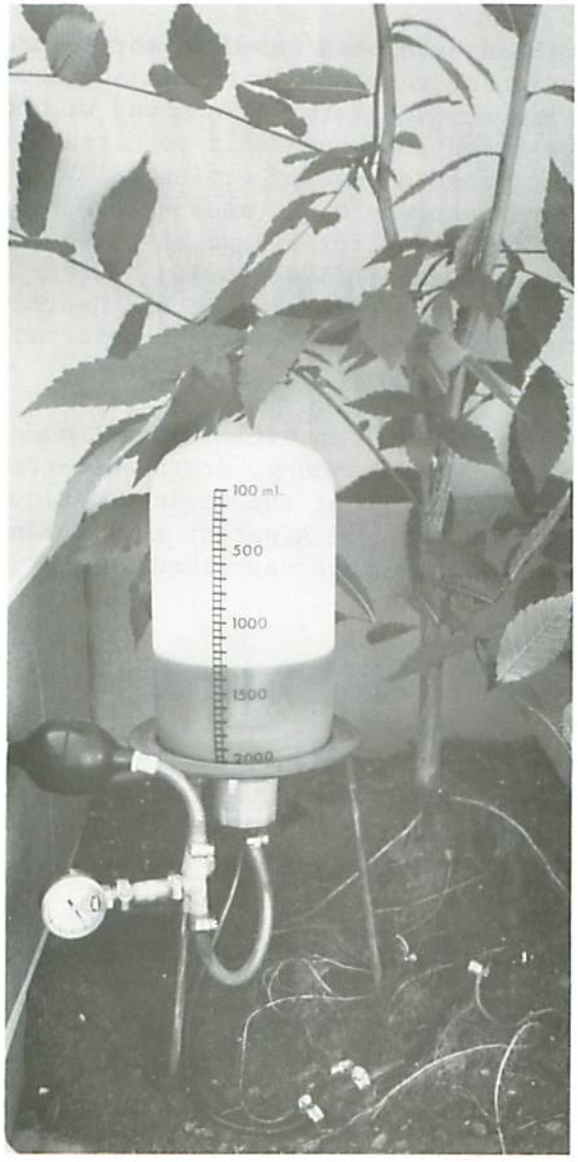

Fig. 1. Apparatus for root injection of young, greenhouse-grown elms under low pressure.

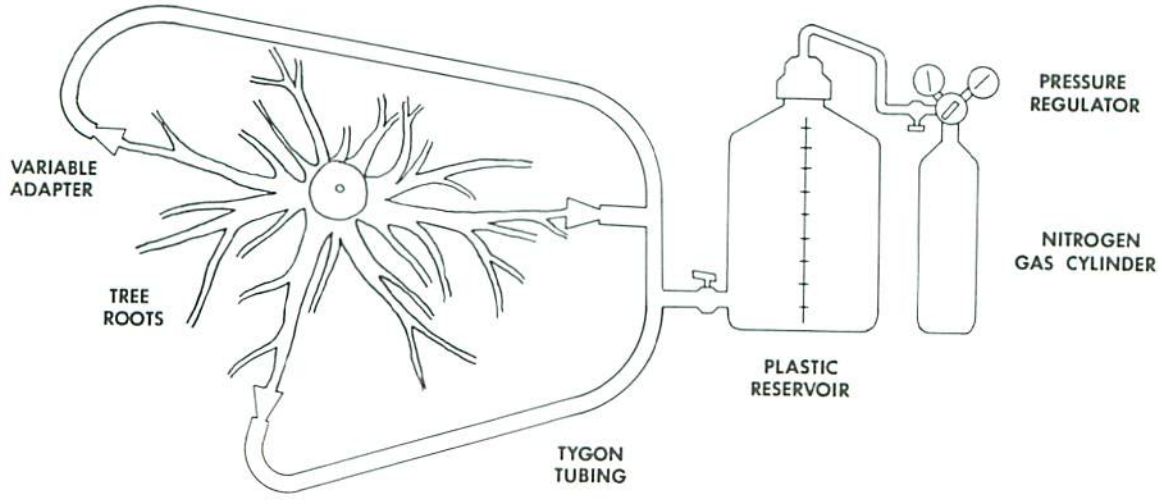

Fig. 2. Apparatus for root injection of mature elms in the field. The severed roots each belong to one of the three major root flares.

The roots of mature elms were carefully excavated outward from the trunk, until three roots approximately 1.3-2.5 cm (1/2-1 in.) in diameter were found. Elm roots commonly fork and are close to the soil surface so that appropriate roots can be easily selected. Care must be exercised during the excavation because the introduced solution could leak from any injuries to the roots.

The selected roots are washed and severed. An anvil-type cutter should be employed to avoid crushing the root and to obtain a smooth-cut surface (Fig. 3). The rubber adapter is slipped on the severed root and clamped (Fig. 4). Immediately, the solution is gravity-fed into the tubing system carefully, to avoid the formation of air bubbles. The time interval between severing the root and applying the liquid should be kept to a minimum. Finally, the reservoir is filled and the pressure adjusted to 10 psi, with the gas regulator valve, and maintained for the duration of the injection period (24-48 hr).

Fig. 3. Severing of a washed root with an anvil-type cutter to obtain a smooth-cut surface.

Fig. 4. Variable rubber adapter attached to a severed root.

RESULTS AND DISCUSSION

Two-year-old greenhouse elms took up approximately 200-300 ml of acid fuchsin solution during a 24- to 48-hr period. The best uptake of solution was obtained with the aid of fans to increase transpiration rates. Dissection revealed that the dye was evenly distributed throughout the seedling in the xylem layer only (Fig. 5).

With field-grown elms, the uptake of the dye solution through root injection was even more dramatic. Healthy elms measuring 15.2-30.5 cm (6-12 in. dbh) took up as much as 30-40 liters (6.6-8.8 gal) of dye solution in a 24-hr period under ideal conditions. Within 48 hr of its application, the dye had stained the entire sapwood evenly, as well as much of the root system (Fig. 6) and almost all the leaves.

In the main bole of the elm, the dye was spread uniformly throughout the sapwood as far as the heartwood. However, dissection of smaller upper branches of the elm revealed that only the outer annual ring of the xylem tissue was stained by the dye. In the leaves the dye was contained in the intercellular spaces of the mesophyll layer. Color photographs of sections of the trunk and branches, and of groups of leaves showing the distribution pattern of the dye are on file at the Great Lakes Forest Research Centre.

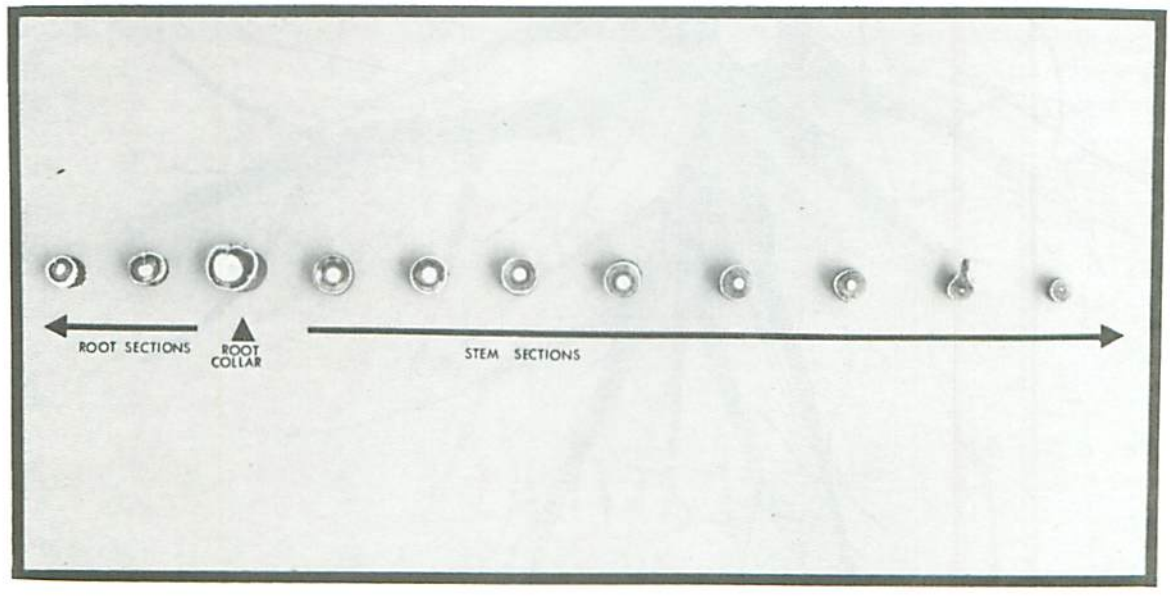

Fig. 5. Cross sections of a 4-ft-high, 2-yr-old greenhouse elm showing distribution of dye 48 hr after root injection.

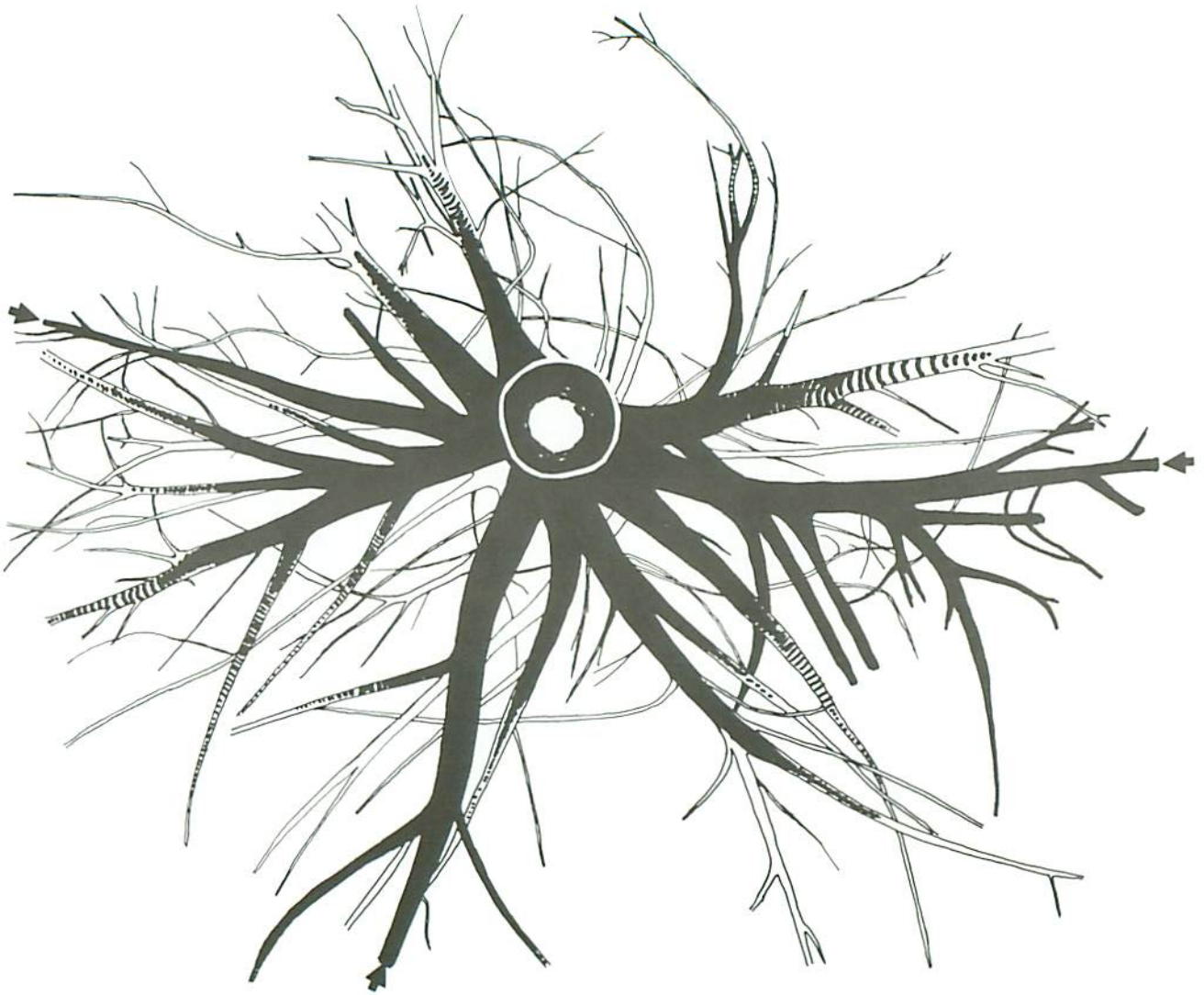

Fig. 6. Root system of a healthy elm 30.5 cm (12 in.) showing distribution of dye (black) 48 hr after root injection through three roots.

Studies revealed that increasing the pressure to 20 psi did not significantly increase the rate of uptake of the solution (Fig. 7). Furthermore, little or no dye was taken up by the tree after 48 hr of continuous root injection into the severed roots. This suggests that after a 48-hr period the wound heals sufficiently to block subsequent attempts at injection of liquids. With smaller elms 10.2-15.2 cm (4-6 in.) dbh introducing the solution via two roots was adequate to obtain fairly uniform distribution of the dye throughout the root system and the remainder of the tree.

Elms exhibiting severe symptoms of Dutch elm disease took up as much of the dye solution as healthy elms of comparable size. This suggests that the wilting of leaves on diseased elms results not merely from the tree's loss of ability to transport water. Dissection revealed that the dye was distributed throughout the diseased elm, in severely wilted leaves and in the area surrounding the brown streaks in the sapwood which are characteristic of Dutch elm disease.

These studies show that there is a direct relationship between the rate of uptake of the solution through the severed roots and factors that normally affect the transpiration rate such as temperature, wind, humidity, light and time of day. The best uptake was obtained on sunny and windy days and the poorest uptake on cold, rainy days.

Experiments to assess the long-term effects of severing roots and subsequent root injection under low pressures were carried out periodically throughout the summer of 1971 with distilled water alone in healthy, mature elms. Examination of these elms in the spring and summer of 1972 showed them to be healthy and unchanged in vigor.

CONCLUSION

In root injection of elms, the choice of the roots for introduction of water-soluble chemicals must be made with care. The best distribution is obtained by choosing for injection one root from each of the major root flares from the trunk of the elm. With elms 15.2-30.5 cm (6-12 in.) dbh, there are usually three major root flares at the base of the tree. Also, the further the point of injection into the root from the trunk of the elm, the better the distribution.

Injection should be limited to warm, sunny days for maximum uptake of solution. Elms may be root-injected from the time the leaves begin to expand in the early spring until leaf senescence. However, maximum uptake and distribution is obtained in the spring and summer when leaves are rapidly expanding and maturing.

Root injection into mature elms of water-soluble chemicals under low pressure, through severed roots, is simple and effective

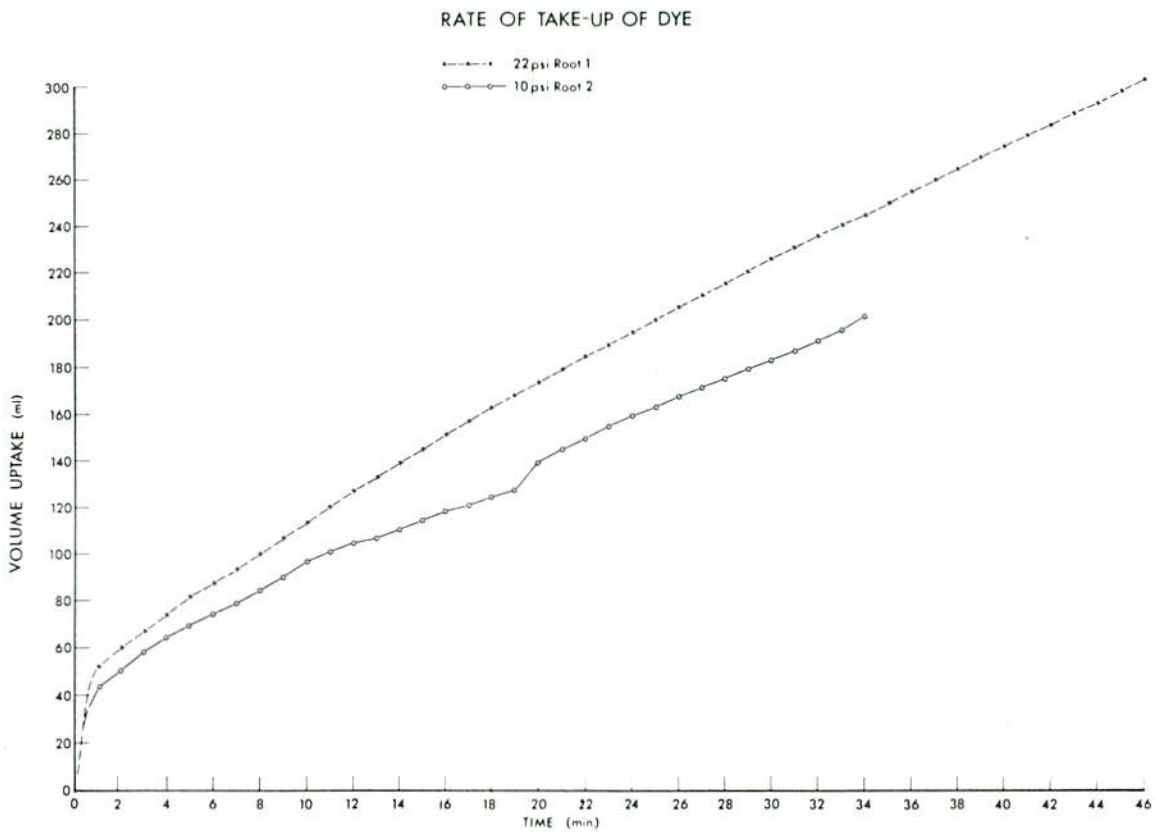

Fig. 7. Rates of uptake of solution during root injection.

and has several advantages.

(1) The solution is distributed uniformly throughout the vascular system of the tree.

(2) Since a large volume is introduced, a lower concentration of chemical can be used, thereby reducing the chemical toxicity at the area of introduction.

(3) The problem of spraying or drenching excess amounts of chemicals is circumvented by introducing chemicals directly into roots.

(4) The wounds created by severing a few roots 1.9 cm (3/4 in.) in diameter in a mature elm will heal rapidly.

This method shows a potential for introducing aqueous chemicals for chemotherapy, systemic chemical protection or fertilization of high-value elm trees, because excellent dye distribution was obtained in both healthy and diseased elms.

A report is being prepared covering the field testing in 1971 of a chemotherapeutant using the root-injection technique described.

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