Measuring Copper Root-Pruning Effect

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Copper root-pruning treatments are now quite commonly accepted as a means of achieving root pruning during plant propagation. Many different formulations of copper treatment can be used. They are commonly manufactured from at least a copper salt and a water-based paint emulsion sticker. Determining whether a product is effective or not is dependent on visual assessment of the root system. There is currently no objective means of ranking the pruning effect. This paper shows that air-filled porosity (AFP) of the growing medium during plant growth can be used to obtain a measure of copper root-pruning effect.

INTRODUCTION

Subjective measures of copper root-pruning effect are normally based on a visual assessment (Figs. 1 and 2). Seedlings are typically easier to extract from the cells if there has been effective root-pruning. These are not easy to measure nor offer an objective means of ranking effect.

Improved seedling growth is sometimes reported (Smith, 1984; Arnold et al., 1993). This could be related to a number of different factors. Copper is an essential nutrient for plant growth, although in excess it can inhibit plant growth by inducing iron deficiency symptoms (Struve and Rhodus, 1990). There is limited, but strong, evidence indicating that copper-containing coatings are severely inhibitory to damping-off pathogens (Brophy et al, 1990). The occasional observation of very large growth differences can possibly be attributed to the copper inhibiting a sub-lethal pathogenic organism. It has been suggested that the increased number of fine root tips occurring with copper pruning allow the root system to explore the substrate volume more completely (Arnold and Struve, 1993). Improved plant growth is not sufficiently constant to consider as a means of measuring copper root-pruning effectiveness.

The use of copper in a container coating is known to produce a structurally different root form of containerised plants (Ruehle, 1985; Hunt, 1990; Smith and McCubbin, 1992; Arnold and Struve, 1993; Stafford et al, 1996). A fine, fibrous root system is commonly reported, as well as a reduction in root weight (Burdett, 1978; Burdett and Martin, 1982; Wenny and Woollen, 1989; Hunt, 1990; Beeson and Newton, 1992). These reports rely on laborious manual means of separating and counting or weighing root components, or on computerised imaging and analysis methods. Some tests require lengthy growing periods after the copper-pruning treatment to assess new root growth. So far, no standardised means of assessing root-pruning effect has been suggested arising from these test procedures.

The marked change in root structure, reduced root weight, and easier extraction of seedlings from treated containers all suggest a smaller root volume. Since the roots must take up a proportion of the total pore space originally present in the growing medium, a simple measure of air-filled porosity should indicate even subtle differences in root volume.

Table 1. Air-filled porosity (AFP) measures (as percent of cell volume) of copper treated containers after tomato seedling growth. The letters represent significant differences (p=0.05) between treatments.

	Trial one		Trial two	
Treatment	AFP	Increase over control (%)	AFP	Increase over control (%)
Control (C)	32.6a	-	18.0a	-
Styhropdip (S)	38.3b	17.5		
Plazdip (P)	45.8c	40.5	23.9b	32.8
Spin Out (S)			24.9b	38.3

A number of trials were conducted over a 6-year period, some including various other heavy metals and variations on type and concentration of emulsion used. Only three trials are reported on here as these indicate best the potential of this air-filled porosity (AFP) method for assessing and comparing copper root-pruning treatments.

MATERIALS AND METHODS

Over the years, I have had occasion to observe root systems of many plant species with and without copper root-pruning treatments. For the purposes of trials, the species chosen must be responsive to copper, readily available, and grow quickly and easily. Tomato seedlings meet these requirements.

In the first trial, seed of tomato FMX785 was sown into Palm Peat (Lignocell, Colombo, Sri Lanka) in injection-molded plastic tubes of an inverted pyramid design, 90 mm deep and 38-ml volume. These tubes were untreated (C), or treated with Styrodip (S) or Plazdip (P) (Starke Ayres, Cape Town, South Africa). Seedlings were watered on demand, and supplied nutrients as Chemicult (Starke Ayres, Cape Town, South Africa).

In the second trial, tomato Scoresby Dwarf seed was sown into New Zealand peat (Watkins, Auckland, New Zealand) into vacuum-formed 84-cell hexagonal seedling trays (Landmark Plastic Corporation, Akron, Ohio, USA) with a cell volume of 22 ml. Cells were untreated (C), or treated with Plazdip (P) or Spin Out (SO) (Griffin Corporation, Valdosta, USA). Seedlings were watered on demand, and supplied nutrients as Peters Excel (Grace Sierra, The Netherlands).

In the third trial, growing conditions similar to the second trial were used, but using Palm Peat (Horticom, Auckland, New Zealand) again. Different levels of copper (as a suspension of tetramino copper sulfate) were included in the Plazdip-type emulsion.

In all cases, AFP measurements were done when the seedlings were judged to be ready for field transplanting. Submerging in water, followed by free drainage until they had stopped dripping saturated the root plugs. The free air space was measured by blocking the base and measuring the volume of water required to saturate the substrate again. This test is a modified version of the method described in AS3743 (Anon., 1989).

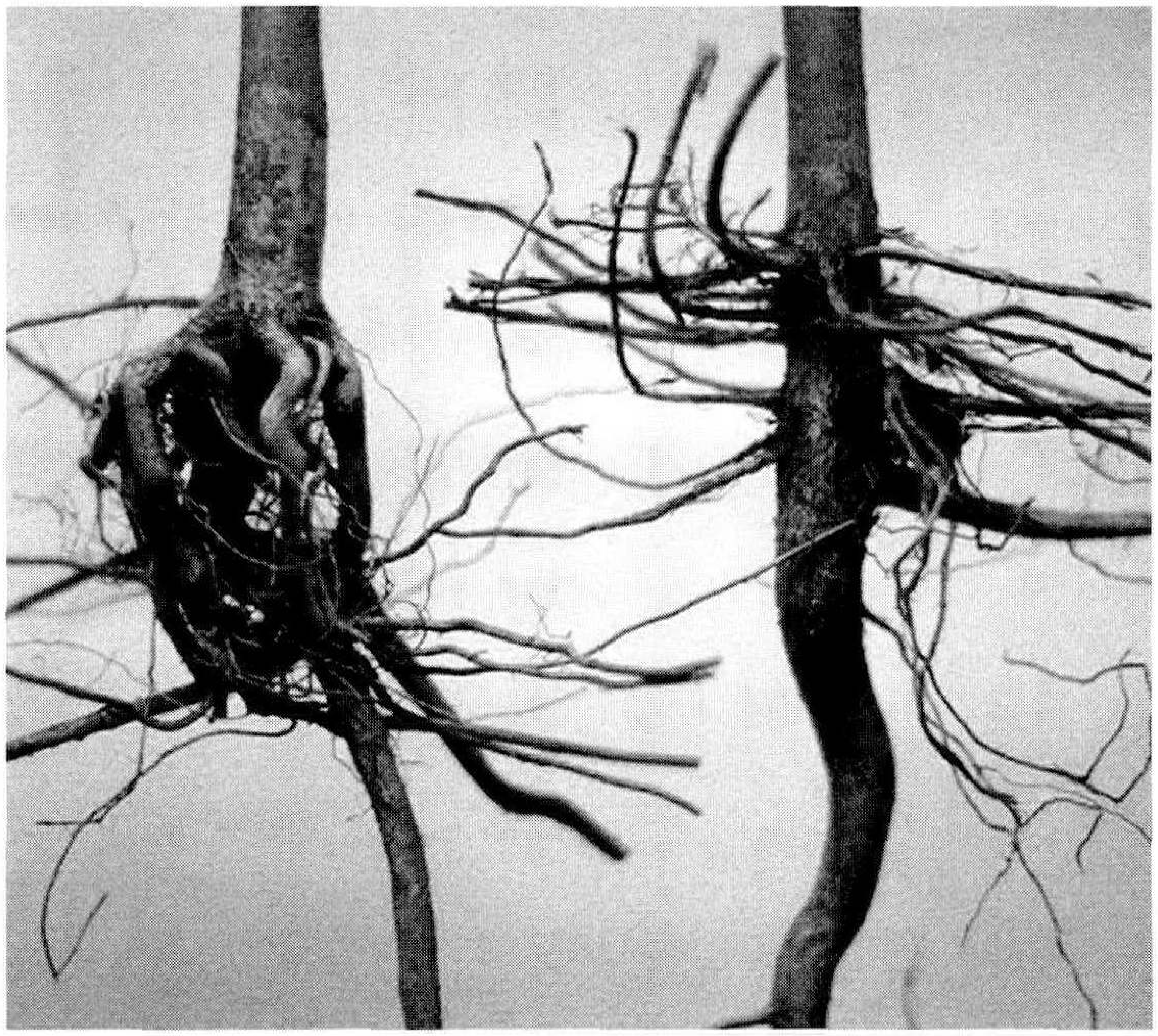

Figure 1.

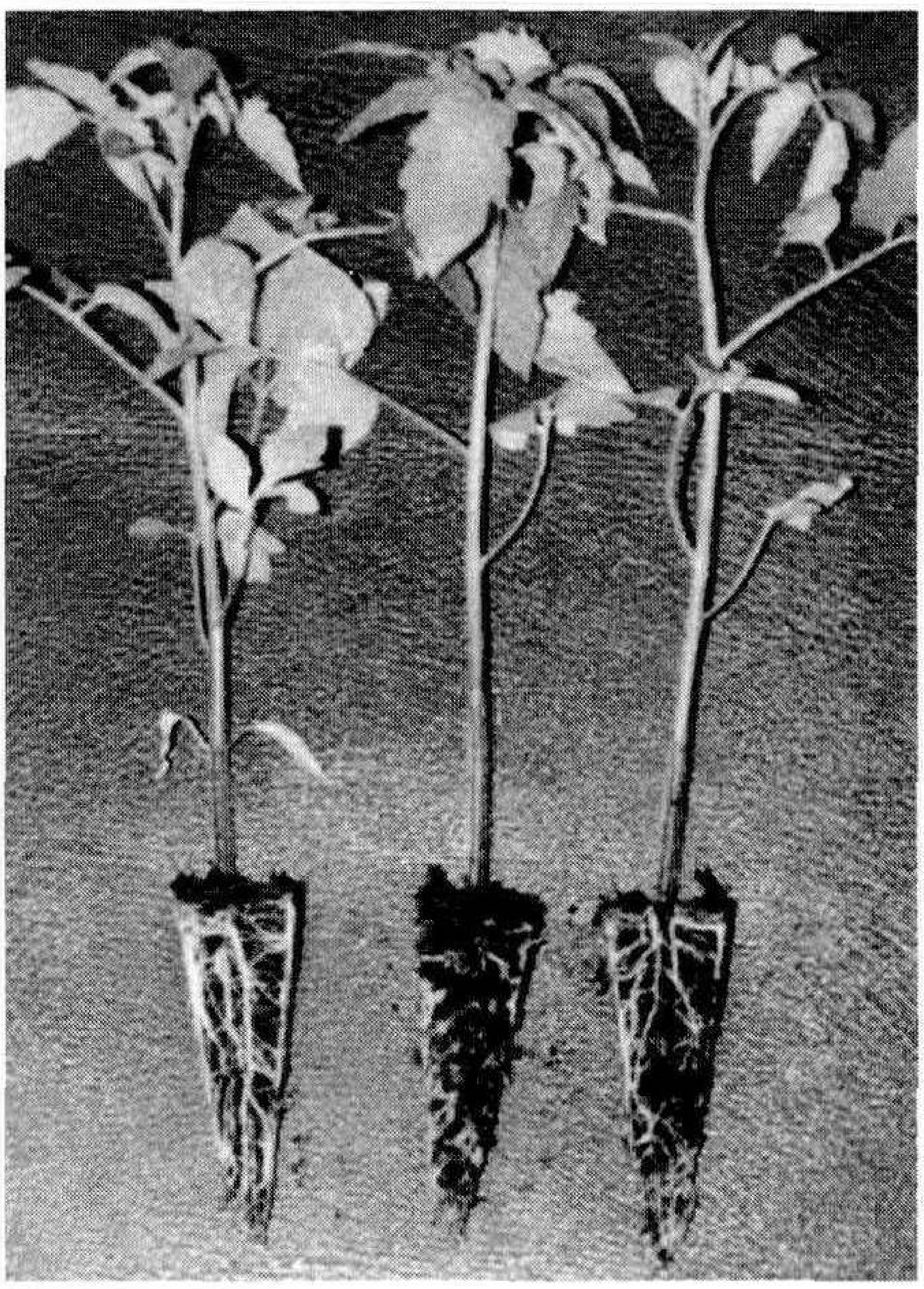

Figure 2.

Figure 3.

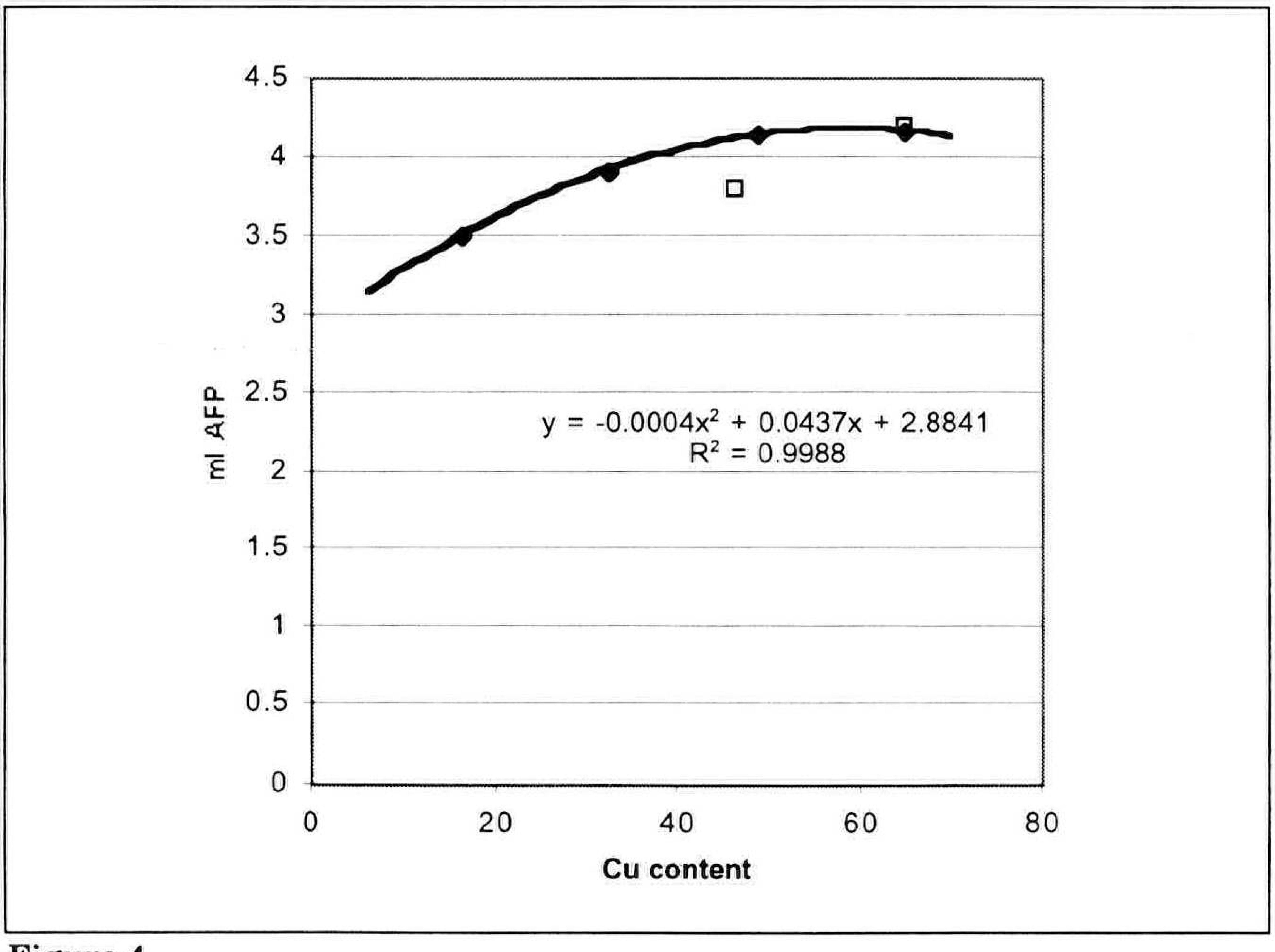

Figure 4.

In all trials, treatments were randomised during the growing period and a visual assessment of the roots was done after AFP measurement. Statistical analysis is by Analysis of Variance.

RESULTS AND DISCUSSION

Significant differences between treatments were noted for both the visual assessments of root pruning (Fig. 2) and the AFP measures (Table 1). The very large differences in measured AFP between the two trials is an indication of the differences between the two forms of peat as well as the deeper cells used in trial one. No direct seedling measures were done, as there was no visual difference in growth of seedlings between treatments at the time of measuring.

Different copper concentrations in the copper treatment illustrate the difficulty of ranking treatments clearly (Fig. 3). In graphical form (Fig. 4), the relative ranking of effectiveness is easy. In addition, it is possible to establish a concentration of copper giving a maximum root-pruning response, in this case about 50 g Cu $litre^{-1}$. The obvious visual differences in root form of tomato seedlings with and without copper pruning are matched by a measurable parameter, air-filled porosity of the substrate. Exactly why the AFP should be higher in the pruned roots is unclear, but could be related to an overall smaller volume of root growth.

In spite of the very large differences in AFP measurements between trials, the AFP of pruned cells is similar when expressed as a percentage of the unpruned cells. This suggests that AFP could be used as a means of assessing effectively any comparison between different formulations of copper-containing products, without having to rely purely on visual assessments of root pruning.

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