Prevention of Phytophthora Root Rot in Pot Plants, a Review

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INTRODUCTION

In 1992 and 1994 experiments showed that the infection of *Phytophthora cryptogea* Pethybr. & Lafferty in *Gerbera jamesonii* L. plants grown in an ebb-and-flow system with recirculation of the nutrient solution could be reduced by increasing the soluble salt concentration measured as electrical conductivity (EC) in the nutrient solution (Thinggaard and Andersen, 1995). The results demonstrated that it was possible to reduce attacks of *P. cryptogea* considerably by elevation of the EC. A reduction in plant death from 74% at EC 1.5 mS cm^{-1} compared with 13% at EC 2.2 mS cm^{-1} was observed. The experiments also showed that *P. cryptogea* zoospores in the nutrient solution could cause an epidemic root attack.

What could be the reason for the decrease in root attacks? What elements in the fertilizer composition could harm the zoospores? It is generally known that copper ions have a fungitoxic effect on *Phytophthora* (Halsall, 1977; Kennedy and Erwin, 1961; Slade and Pegg, 1993). Could it be the elevation of copper from 0.07 to 0.12 ppm in the nutrient solution?

MATERIALS AND METHODS

In two experiments in 1996, the concentration of copper ions was increased from 0.07 to 0.28 ppm in the nutrient solutions with EC 1.5 or 2.2 mS cm^{-1}. *Gerbera jamesonii* plants were inoculated with zoospores of *P. cryptogea* and *Hedera helix* L. with zoospores of *P. cinnamomi* (Toppe and Thinggaard, 1998; Toppe and Thinggaard, 1999). Both cultures were grown in ebb-and-flow systems with recirculation of nutrient solutions. The iron source was iron sulphate and in *Gerbera* both iron sulphate and iron chelate were used.

RESULTS

In *Gerbera* as well as in ivy the results clearly demonstrate the positive impact of elevated copper ion concentration in the nutrient solution for prevention of Phytophthora root rot. By increasing the level of copper ions from 0.07 to 0.28 ppm the disease severity was reduced in *Gerbera* at all inoculum levels tested, when iron sulphate was used as iron source (Fig. 1). No significant differences between the two EC levels were observed. No reduction in disease was observed in *Gerbera* when iron chelate was used.

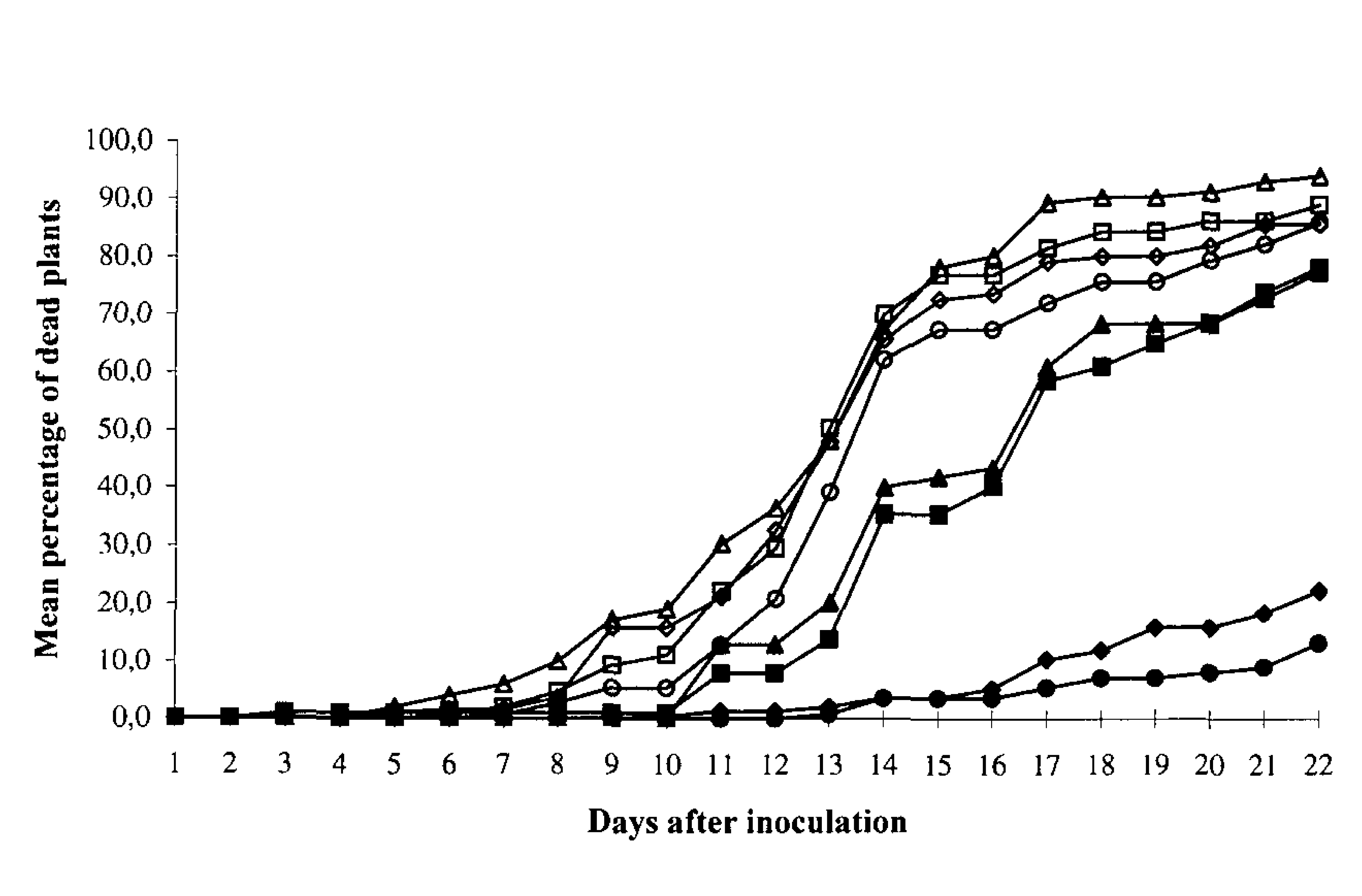

Figure 1. Mean percentage of dead *Gerbera jamesonii* plants infected with Phytophthora root rot. Plants were grown in nutrient solutions of different EC (1.5: ■, ●, □, ○ or 2.2: ▲, ◆, △, ◇) with copper sulphate of different concentrations (0.07 ppm: ■, □, ▲, △ or 0.28 ppm: ●, ○, ◆, ◇). Nutrient solutions with iron sulphate (closed symbols) or iron chelate (open symbols). The results were recorded every other day after inoculation with *P. cryptogea*. Mean values of three experiments.

DISCUSSION

Elevation of the copper-ion concentration caused an even bigger reduction in the attack of *P. cinnamomi* in ivy than in *G. jamesonii* inoculated with *P. cryptogea*. The observed effect of increased copper ion concentration is most likely due to copper sensitivity of the cell wall free zoospores. The reduced availability of cupric ions is most likely due to the complex binding to humic substances in the solution (De Kreij and Basar, 1995). In spite of this reduction in cupric ion concentration, a copper level of 0.28 ppm as used in these experiments was sufficient for a significant inhibition of disease attack. Low cupric-ion concentrations between 0.06 and 1 ppm Cu^{++} have previously been reported to inhibit sporangial production in *P. cinnamomi* (Halsall, 1977). Mycelia of *P. cinnamomi* are reported to be killed when immersed for 24 h in suspensions containing 13 to 45 ppm copper (Smith, 1979). This indicates that higher copper concentrations are necessary to inhibit mycelial growth compared to those concentrations needed to inhibit sporangia formation and zoospores. The copper level used in our experiments would, thus, inhibit the zoospores in the nutrient solution, but not mycelial growth, oospores, or germination of encysted zoospores.

The present results suggest that the preventive effect of increased EC observed by Thinggaard and Andersen (1995) could be explained by an increased level of specific ions in the solution rather than as a general effect of increased EC. *Phytophthora* is known to cause high infection rates due to short latent periods and rapid production of high numbers of zoospores, whereby the introduction of a small amount of inoculum in the growing system could be of considerable risk. Thus, there might be a great potential for effective control of *Phytophthora* by elevating the copper concentration in the early stage of an epidemic disease.

In practice the amount of copper added to the nutrient solution must be adjusted regularly to provide a concentration lethal to the pathogen. Earlier investigations have also demonstrated metal chelates to reverse the suppressive effect of increased copper concentration (Halsall, 1977; Kennedy and Erwin, 1961). Therefore, alternatives to metal chelates as iron source, e.g. chelates with stronger binding of iron ions or $FeSO_4$ at the right concentrations, must be found before the enrichment of copper would be recommended for disease control in commercial production.

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