Propagation of *Anemone* ×*hybrida* by Root Cuttings

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Stock plants of *Anemone* ×*hybrida* Paxton 'Honorine Jobert' and 'Richard Ahrends' were grown in 3.8-liter (#1) containers beginning April 1998, and fertilized daily with a nutrient solution providing 10, 40, 80, or 150 mg liter^{-1} (ppm) nitrogen (N). After 30 weeks (November), root cuttings were harvested from the stock plants and treated with K-IBA at 0, 100, 500, or 1000 mg liter^{-1} (ppm), then placed in cell packs, one cutting per cell. The containers were arranged under intermittent mist in a heated greenhouse. Overall, 91% of the cuttings regenerated a new plant. There were cultivar differences in percent regeneration, and the highest K-IBA concentration was inhibitory to 'Honorine Jobert', but not to 'Richard Ahrends'. Time to emergence of a shoot was reduced by higher rates of N applied to the stock plants, and increased at the highest concentration of K-IBA in 'Honorine Jobert'. Dry weight of the regenerated plants increased with increasing weight of the cuttings from which they originated, and was linearily related to rate of N applied to the stock plants in 'Honorine Jobert', and quadratically in 'Richard Ahrends', with maximum plantlet weight predicted at 114 mg liter^{-1} (ppm) N. At the observed optimal rate of N applied to the stock plants, maximum plantlet weight is predicted at 459 mg liter^{-1} (ppm) K-IBA in 'Honorine Jobert', and at 425 mg liter^{-1} (ppm) in 'Richard Ahrends'.

INTRODUCTION

Fall-flowering anemones are highly sought after perennials whose widespread acceptance in the landscape has been hampered by propagation difficulties. Growing in partial shade, they are robust, adaptable plants within the limits of U.S.D.A. cold hardiness Zones 5 to 8. Once established, they spread, sometimes aggressively, by means of shoots developing in great numbers along the entire length of the roots (Huxley, 1992; McKendrick, 1990). In a survey of perennial propagation firms across the United States conducted by the authors, fall-flowering anemones were the plants most often cited as needing improvement in propagation.

Currently, propagation is accomplished by division or root cuttings, with very low multiplication rates in either case. Published information regarding this topic is limited to general recommendations on handling of root cuttings (Fisher, 1961; Hartmann et al. 1997; Kessel, 1986; McKendrick, 1990), and based on scant research involving woody species (Del Tredici, 1995; Peterson, 1975).

In *Chondrilla juncea* L. (skeleton weed) and *Euphorbia esula* L. (leafy spurge), several studies have shown a positive correlation between high N levels in the growing substrate of stock plants, and both the number of shoot buds produced on their roots and the ability to regenerate whole plants from root segments (Kefford and Caso, 1972; McIntyre, 1972). In stem cuttings, however, adventitious root formation has been shown to be affected negatively by high N nutrition of stock plants (Blazich, 1988). Therefore, the following investigation was undertaken with two cultivars of fall-flowering anemone to (1) determine the effect of N nutrition of stock plants on propagation by root cuttings, (2) study the influence of K-IBA treatment of root cuttings on plantlet development, and (3) provide the basis for a practicable system for production of plantlets of anemone in small cell containers with a high success rate.

MATERIALS AND METHODS

Sixty four #1 field divisions each of cultivars 'Honorine Jobert' and 'Richard Arhens' anemone were grown for 30 weeks, beginning April 1998, in 3.8-liter (#1) containers filled with a substrate of composted pine bark and sand (8:1, v/v), amended with 2.4 kg m^{-3} (4 lb yd^{-3}) dolomitic limestone and 0.9 kg m^{-3} (1.5 lb yd^{-3}) MicroMax (The Scotts Co., Marysville, Ohio). Plants were fertigated daily via pressure-compensated spray stakes with a nutrient solution providing 10, 40, 80, or 150 mg $liter^{-1}$ (ppm) N in a constant ratio of 1 ammonium : 2 nitrate, in addition to P, K, Ca, Mg, and S at constant concentrations.

After 30 weeks (November), root cuttings 4 cm (1.6 inch) in length were harvested from the stock plants, weighed individually, and dipped for 5 sec in K-IBA at 0, 100, 500, or 1000 mg $liter^{-1}$ (ppm), then placed in bedding plant containers (9 × 4 cells, No.1020 flat) containing a pine-bark-based substrate, one cutting per cell [cell vol. = 160 cm^3 (9.8 $inches^3$)], and covered with 1.5 cm (0.6 inches) substrate. Containers were placed under intermittent mist in a heated greenhouse under natural photoperiod and irradiance with mean day/night temperatures of 24 ± 1.7°C (75 ± 3°F) and 20 ± 1°C (68 ± 2°F), respectively. Mist was applied via a gantry-mounted traveling spray boom (ITS, McConkey Co., Sumner, Wash.) with continuous regulation of frequency as a function of relative humidity, and traveling speed adjusted to 15 m min^{-1} (50 ft min^{-1}). This setting resulted in the medium surface just reaching dryness before being misted again. The experiment was a randomized complete block design with a factorial arrangement of treatments: two cultivars, four rates of N applied to the stock plants, and four rates of K-IBA applied to the root cuttings. There were six replications with six cuttings per replication. After 8 weeks, misting was discontinued, and plantlets were irrigated overhead every 3 days. After 12 weeks, roots of the resulting plantlets were washed free of substrate, and separated from the shoots. Roots and shoots were dried 96 h at 70°C (160°F), and weighed. Data were subjected to analysis of variance and regression analysis where appropriate. Effects of cutting weight were analyzed by analysis of covariance, with cutting weight as the covariate.

RESULTS AND DISCUSSION

Percent Regeneration. Percent regeneration across cultivars and treatments, as measured by the proportion of root cuttings that resulted in a complete, viable plantlet, was 91%. There was a significant difference between the two cultivars, with 'Honorine Jobert' averaging 84% across all treatments, and 'Richard Ahrends', 98%. Weight of the root cutting and rate of N applied to the stock plant did not affect percent regeneration in either cultivar, while response to K-IBA was quadratic in 'Honorine Jobert', with a maximum of 90% regeneration predicted at 240 mg $liter^{-1}$ (ppm) K-IBA (Fig. 1). Percent regeneration was unaffected by K-IBA in 'Richard Ahrends'.

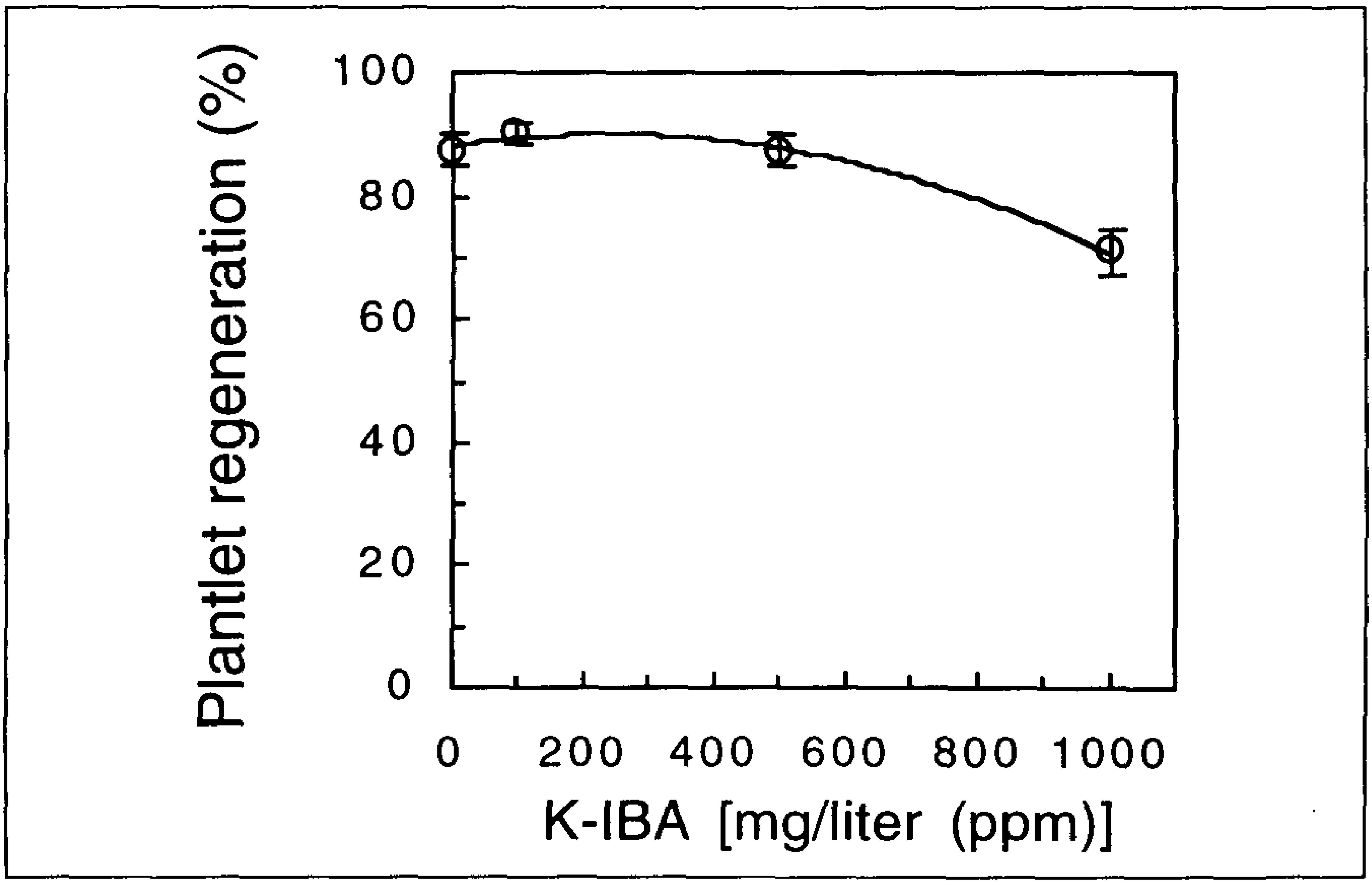

Figure 1. Effect of K-IBA treatment on percent regeneration of 'Honorine Jobert' anemone from root cuttings. Each point represents the mean of 24 observations. Vertical bars are the standard error of the mean. r^2=0.9947.

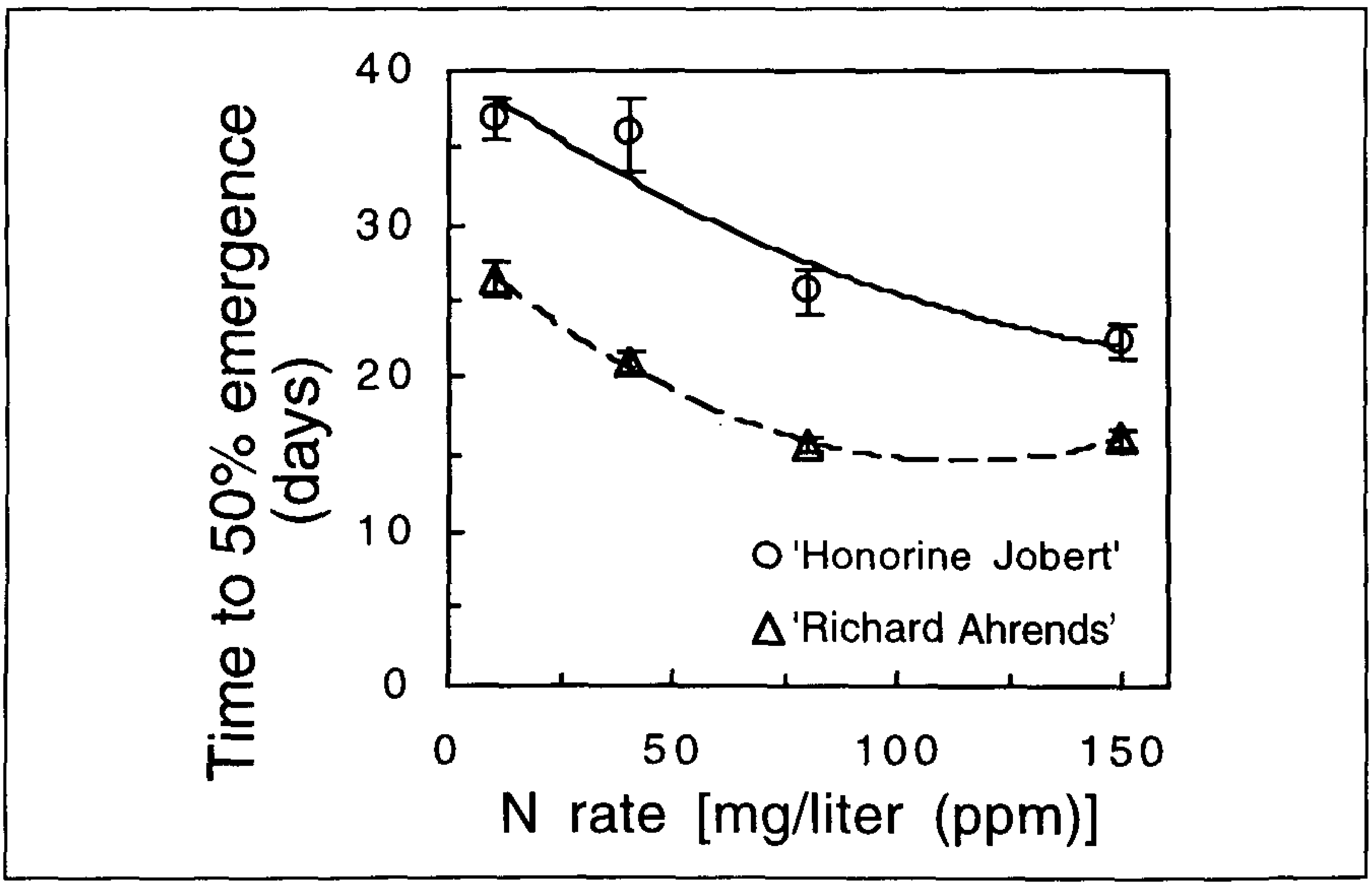

Figure 2. Effect of rate of nitrogen applied to the stock plants on time to 50% shoot emergence from root cuttings. Each point is the mean of 24 observations. Vertical bars are the standard error of the mean. 'Honorine Jobert' r^2= 0.8897. 'Richard Ahrends' r^2 = 0.9983.

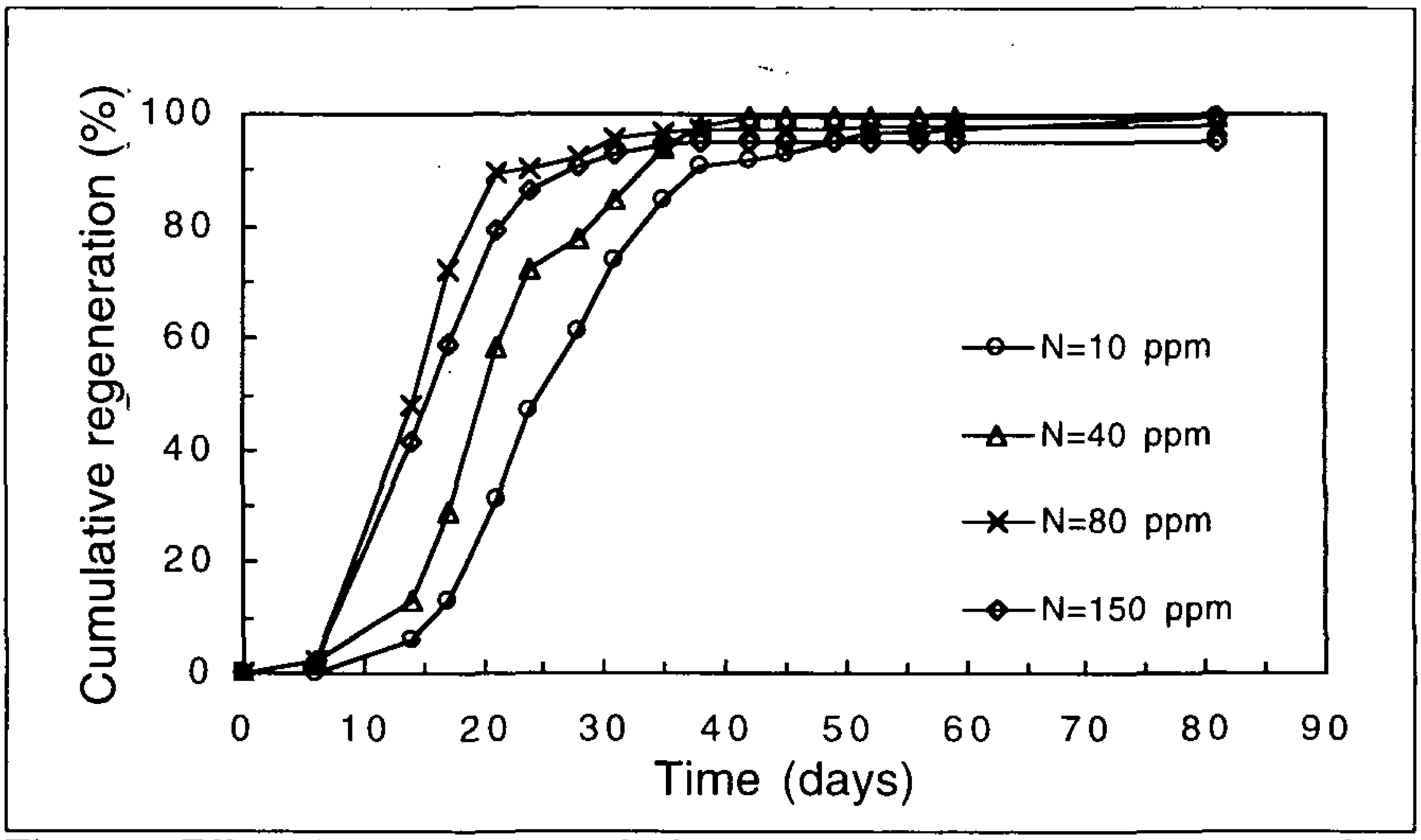

Figure 3. Effect of nitrogen rate applied to stock plants on cumulative percent shoot emergence over time in root cuttings of 'Richard Ahrends'. Each point represents the mean of 24 observations.

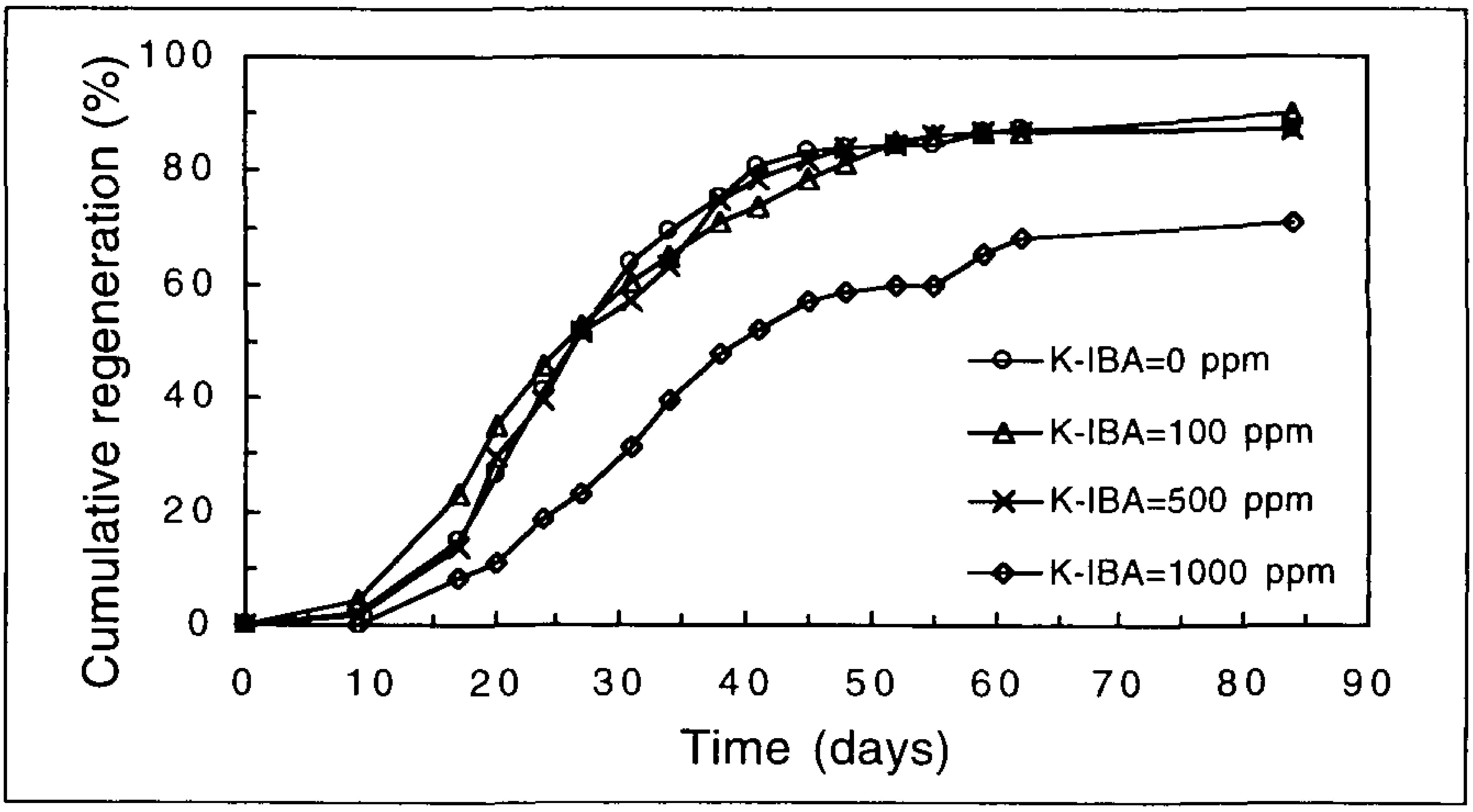

Figure 4. Effect of K-IBA on cumulative percent shoot emergence over time in root cuttings of 'Honorine Jobert' . Each point represents the mean of 24 observations.

Time to Emergence. 'Honorine Jobert' reached 50% emergence in 30 days, and 'Richard Ahrends' in 20 days. Cutting weight did not affect time to 50% emergence. The relationship between time to 50% emergence and rate of N was linear in 'Honorine Jobert' and quadratic in 'Richard Ahrends' (Fig. 2). Increasing rate of N applied to the stock plant shortened time to emergence in both cultivars. For 'Richard Ahrends' the fastest emergence (15 days) is predicted to occur at 114 mg liter^{-1} (ppm) N (Fig. 3).

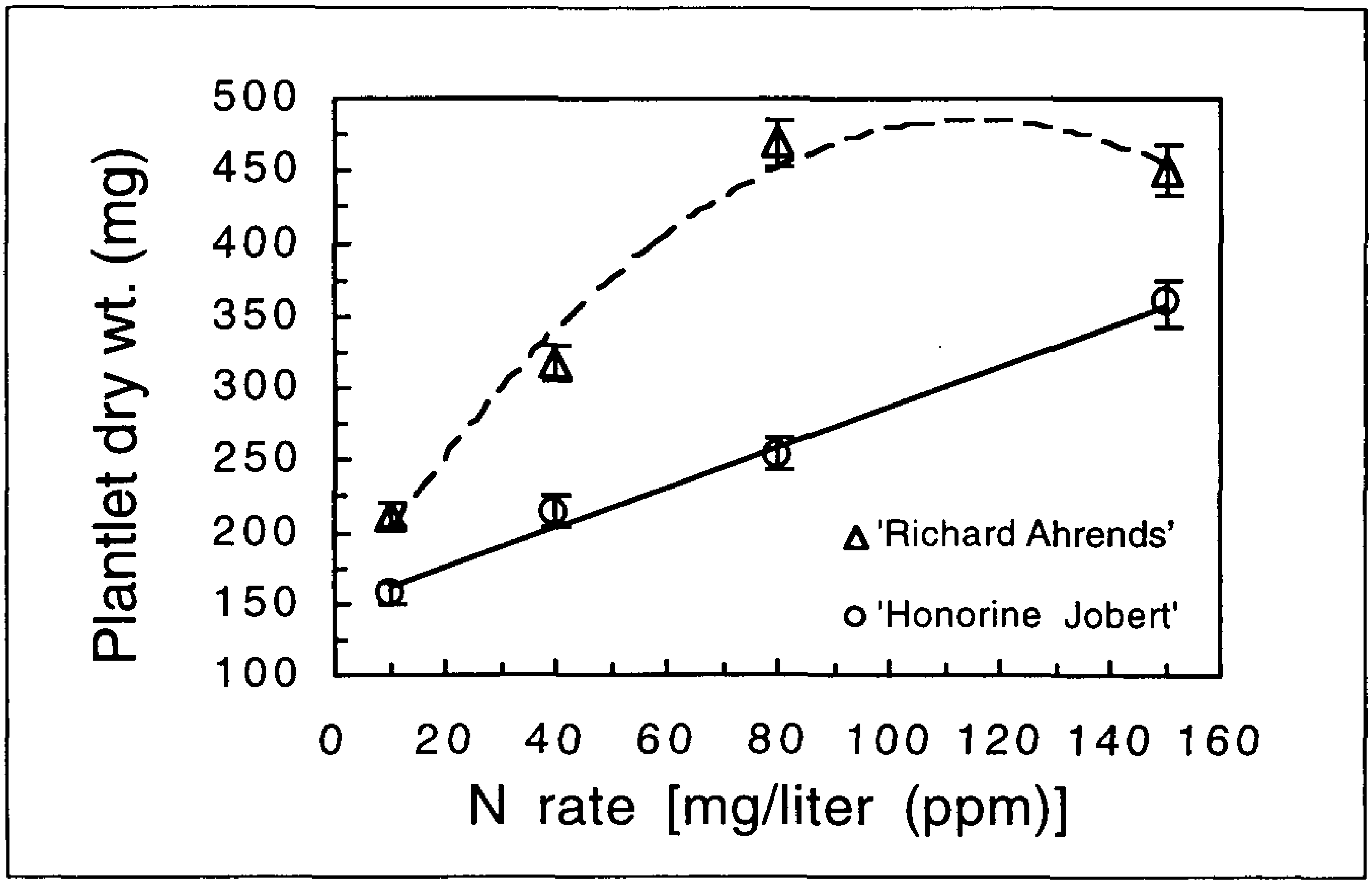

Figure 5. Effect of nitrogen rate applied to stock plants on dry weight of plantlets regenerated from root cuttings. Each point represents the mean of 114 to 133 observations for 'Honorine Jobert', and 136 to 143 observations for 'Richard Ahrends'. Vertical bars are the standard error of the mean. 'Honorine Jobert' r^2= 0.9922. 'Richard Ahrens' r^2= 0.9788.

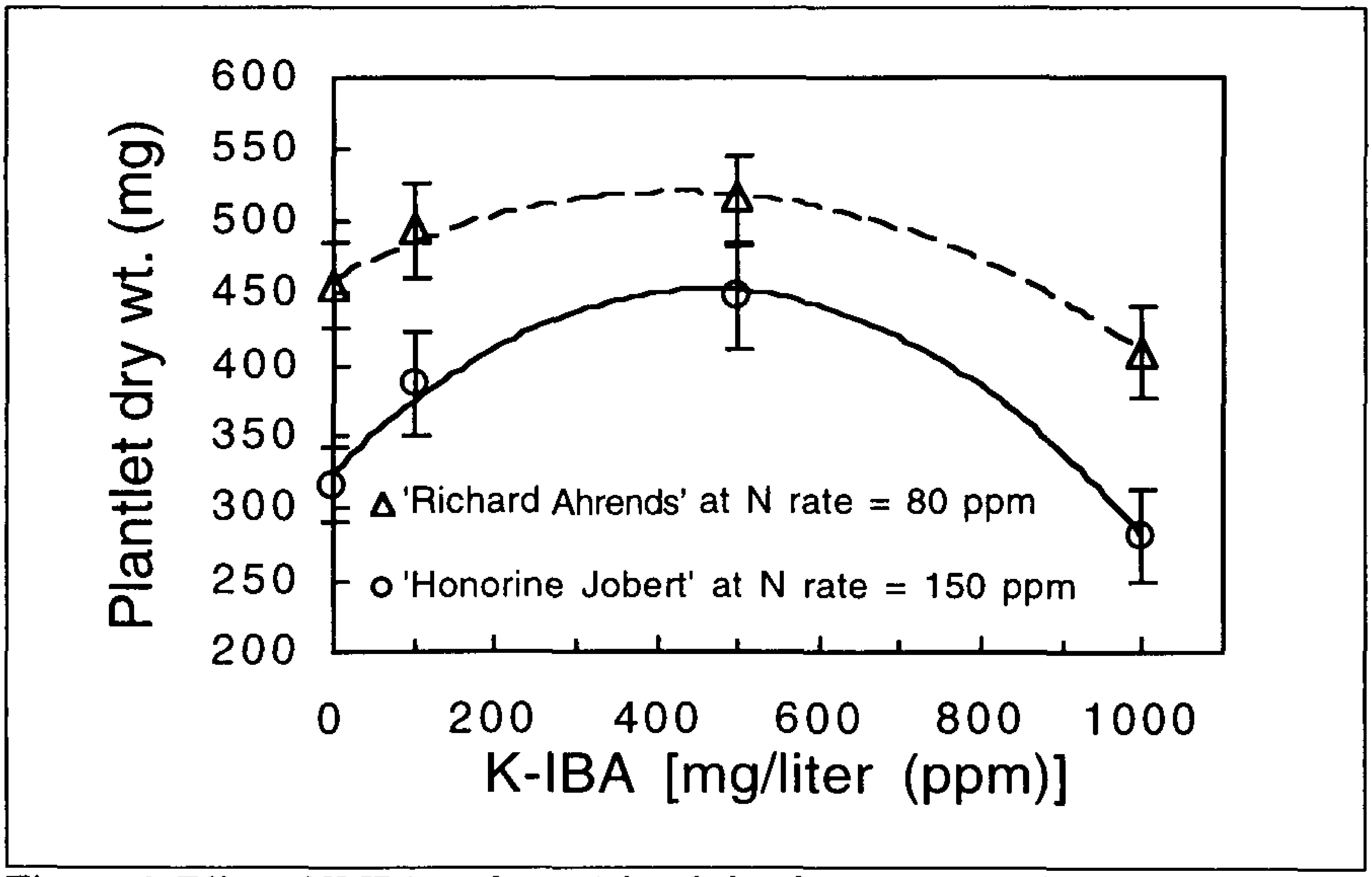

Figure 6. Effect of K-IBA on dry weight of plantlets regenerated from root cuttings. Each point represents the mean of five observations, one observation is six cuttings. Vertical bars are the standard error of the mean. 'Honorine Jobert', at rate of nitrogen applied to the stock plant = 150 mg liter^{-1} (ppm). r^2= 0.9839. 'Richard Ahrends', at rate of nitrogen applied to the stock plant = 80 mg liter^{-1} (ppm). r^2= 0.9836.

Time to emergence was unaffected by K-IBA in 'Richard Ahrends', whereas increasing K-IBA concentration delayed emergence in 'Honorine Jobert' (Fig. 4). The latter cultivar exhibited a quadratic increase in time to 50% emergence with increasing K-IBA concentration, with an observed maximum mean time to 50% emergence of 38 ± 2 days at 1000 mg liter^{-1} (ppm) K-IBA.

Plantlet Dry Weight. Overall mean plantlet dry weight was 245.6 mg (0.009 oz) for 'Honorine Jobert', and 362.2 mg (0.013 oz) for 'Richard Ahrends'. Cutting fresh weight had a strong positive influence on dry weight of the resulting plantlet. The slope of the covariance adjustment was 0.92 ± 0.10 for 'Honorine Jobert', and 1.14 ± 0.09 for 'Richard Ahrends'. From this, we concluded that within the range used in this experiment, each unit increase in cutting fresh weight will result in approximately one unit increase in the dry weight of the plantlet produced from that cutting.

Plantlet dry weight increased linearly with increasing N in 'Honorine Jobert', and responded quadratically in 'Richard Ahrends', with maximum plantlet weight predicted at 115 mg liter^{-1}(ppm) N in this cultivar (Fig. 5). The largest mean dry weight by rate of N was 358 mg for 'Honorine Jobert', observed at 150 mg liter^{-1} (ppm) N, and 469 for 'Richard Ahrends', at 80 mg liter^{-1} (ppm) N.

At those respective rates of N, plantlet dry weight responded to K-IBA in a quadratic manner in both cultivars. However, there was no overall interaction between rate of N and K-IBA. Maximum response is predicted to occur at 459 mg liter^{-1} (ppm) K-IBA in 'Honorine Jobert', and at 425 mg liter^{-1} (ppm) in 'Richard Ahrends' (Fig. 6). At these concentrations, a 37% increase in plantlet dry weight would be expected in 'Honorine Jobert', as compared to not using any K-IBA. In 'Richard Ahrends', the increase would be expected to reach 13%. At those concentrations, K-IBA would not affect percent regeneration or rate of shoot emergence.

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