We graft many different trees: *Betula*, *Carpinus*, *Crataegus*, *Fagus*, *Fraxinus*, *Malus*, *Prunus*, *Sorbus*, *Quercus*, *Syringa*, and *Tilia* with good results. Species as different as these have very different growth rhythms, however, they can be treated in the same way because we believe the most important factors are the energy level and water content of the plant.

Transplanting is made in fertilized and deeply prepared soil that can be irrigated. Rootstock sprouts are removed in June when they are small, and again in August. New leader shoots are tied up in June and unnecessary shoots are removed.

INCOMPATIBILITY

False incomparability is due to poor grafting work and is a result of excessive callus growth which rejects the scion. Such grafts should be discarded during the first season as they will, in most cases, break before the saleable size is reached. Genuine incompatibility is often seen in *Quercus* and *Fagus* and is more problematic because the symptoms frequently are delayed 10 to 20 years.

Growing Pot Plants with Reduced Phosphorus can Improve Root Structure and Avoid Drought Stress

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INTRODUCTION

To increase consumer satisfaction, growers have to produce high-quality plants which are compact, stress tolerant, and free from diseases. This often does not harmonize with growers attempts to keep the production period as short as possible by growing bedding plants with optimum light, temperature, and a surplus of fertilizer to maximize growth rate. Such conditions often produce plants with elongated, lush shoots. However, this is at the expense of root development, and in turn poor stress tolerance. Therefore, it is recommended that before shipping growers harden their plants by giving a short period of lower temperature and reduced fertilizer and water at the end of the production cycle (Serek, 1990). This practice encourages root growth at the expense of shoot growth and is advantageous because plants with well developed root systems which exploit the medium uniformly and with room for further growth are best at withstanding the fluctuations in soil moisture which occur during shipping, handling, and in the hands of the consumers.

REDUCED PHOSPHORUS LEVEL

It is possible to improve plant quality and stress tolerance even more by encouraging strong root growth during production by reducing the phosphorus (P) levels in the root zone. Ornamental plants are typically grown with phosphorus levels much higher than those found in fertile soils. This may have detrimental effects. Studies using alumina-buffered phosphorus fertilizer (Al-P) show that plants can grow well at P levels as low as 10 μM P (Lynch et al., 1991). We have investigated the effects of reduced phosphorus (1/50 of the concentration traditionally used) on development and quality in marigold (*Tagetes* Janie Tangerine^{TM}). We specifically tested the hypothesis that low P would improve resistance or avoidance of postproduction drought stress in this bedding plant. We found that when plants grown with Al-P were exposed to drought at the marketing stage, they respired less water (Fig. 1) and, therefore, wilted more slowly compared to high P control plants. The low P treatment resulted in a 50% reduction in leaf area which will naturally reduce the transpiration allowing the plant to avoid drought for extended periods. The overall size of the plants was not reduced and the reduction in leaf area did not affect the appearance significantly.

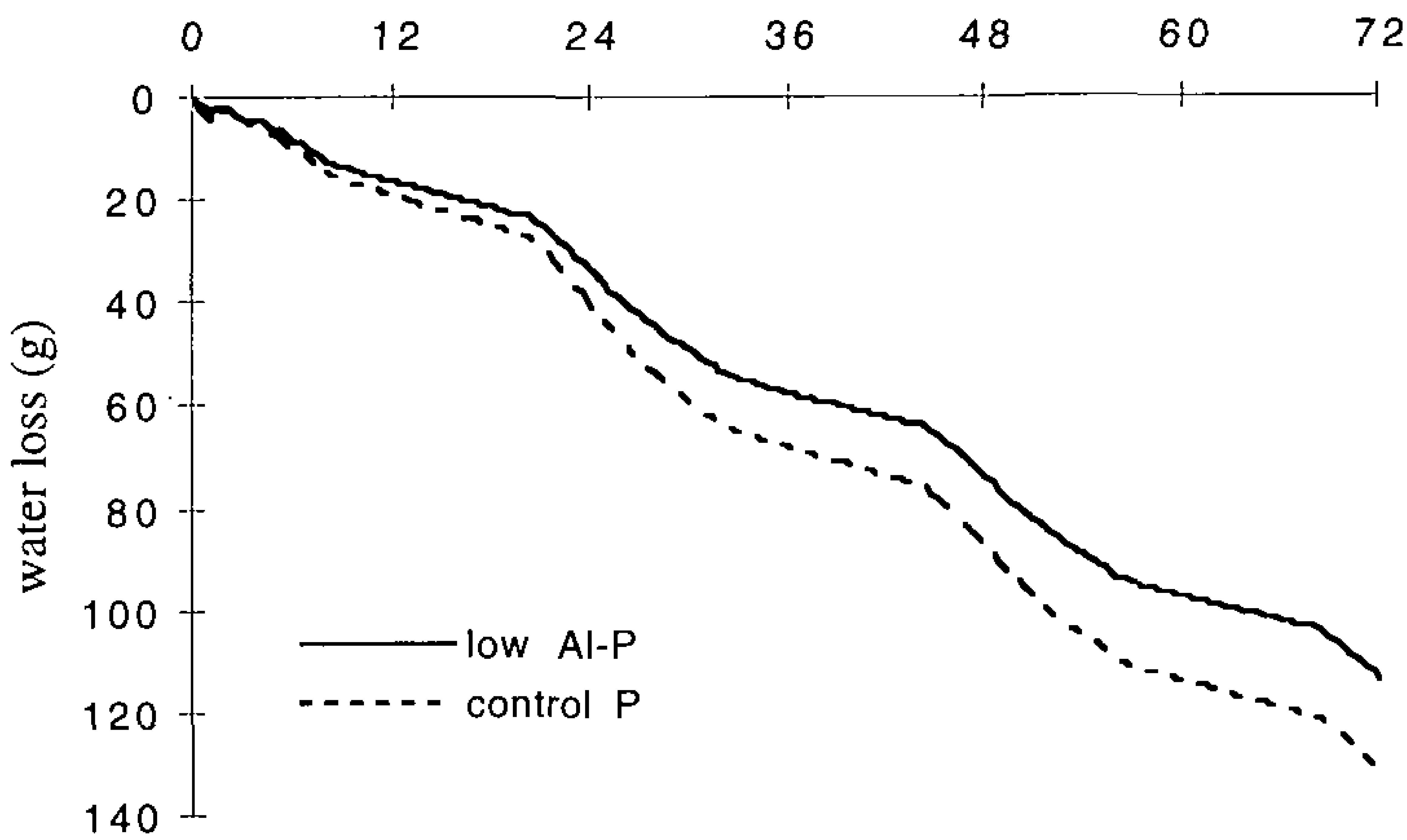

Figure 1. Transpiration monitored as gravitrometric water loss (transpiration) from the growth media of marigolds (*Tagetes* Janie Tangerine™) in 10-cm pots at anthesis grown with two levels of P (control P and low P (Al-P)) for 72 h. Values are means of eight plants.

The roots in the Al-P-buffered plants were more evenly distributed throughout the growth medium whereas the roots in the high-P control plants were confined to an area under the drip tube (Fig. 2). The explanation of this improved root distribution is probably the lack of a guiding P gradient in the Al-P-buffered growth medium. In contrast drip irrigation will create a high P concentration in the drip area guiding the roots to proliferate in this constricted area. Thus, reduced leaf area together with improved root distribution in marigold plants may account for the improvement in drought avoidance in the Al-P plants.

ROOT STRUCTURE

Root structure is very important for P acquisition when P resources are scarce because root uptake of P is predominately by diffusion, due to the very low concentrations of this ion in the free soil solution (Barber, 1995). Simultaneously, root architecture, proliferation, and mass affect the rate at which root systems remove moisture from soils (Faber et al., 1991) because the water flow in soil is often the largest resistance for the soil-plant-atmosphere continuum (Nobel, 1991). Therefore, we investigated if the improved drought resistance in low-P plants could be related to improved root structure. It was evident that the plants responded to reduced P availability by decreasing lateral root density and increasing root length at the expense of shoot growth. When lateral root density is decreased and root

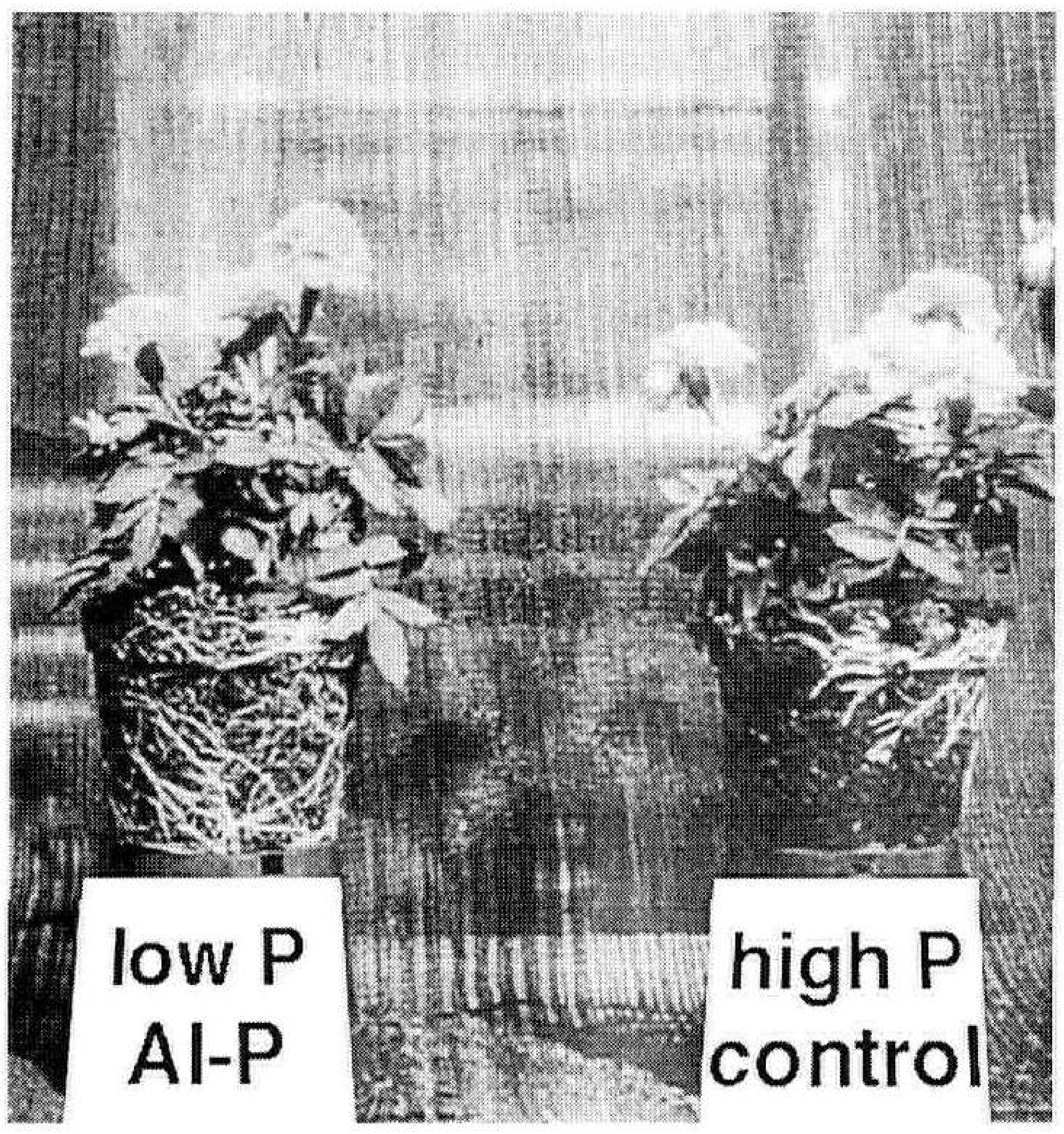

Figure 2. Marigold (*Tagetes* Janie Tangerine™) fertigated with high P, or buffered with low P concentration from alumina charged with P amended in the growth medium. Note how the root of the high P control plant is restricted to an area right under the drip tube.

length is increased soil volume exploration will be enhanced increasing the possibility of finding a P-rich patch in which it will branch vigorously to exploit the P (Snapp et al., 1995). This will also have a positive effect when water becomes depleted and the transport distance becomes larger, because a reduced lateral root density will give a better "space-filling" capacity and an improved ability to explore the medium for water (Fitter, 1986) avoiding drought stress. On the other hand, increased lateral root density is expected to become irrelevant for water uptake resistance during low water potentials in the pot because the depletion zones overlap (Fitter et al., 1991).

Thus, reduced P will improve root structure and the space-filling capacity enhancing water utilization. Moreover, the decreased leaf area will also reduce momentary water uptake and thereby save water resources. Both these features can improve water stress avoidance by the plant. If we better understand the changes in root architecture and morphology that occur during low-P conditions, it will enable us to prepare an ideal root zone which will allow maximum growth and development of the root system and thereby improve plant tolerance to stress factors.

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