SUPPLEMENTAL LIGHTING IN THE PROPAGATION OF DECIDUOUS AZALEAS[1]

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Abstract. Literature pertinent to the influences of light intensity, light quality and photoperiod on propagation of ornamentals is presented. Direct effects, as well as effects mediated through the stock plant are discussed. In addition, research is reported which illustrates improved microcutting production and rooting when hardy deciduous azalea microstock cultures were illuminated with reduced light intensities, or when subjected to 2 weeks of red light after 2 weeks of far-red light prior to rooting.

REVIEW OF LITERATURE

Light influences propagation success in many ways. In addition to the obvious advantage of greater carbohydrates and other substances necessary for rooting which may be produced by any treatment enhancing photosynthesis, it is clear that light has many other striking effects. These may include: direct stimulation of rooting by light intensity or photoperiod modifications; a change in amount of cuttings produced and/or improved rootability caused by different stock plant light treatments; improved growth and survivability of cuttings as a result of lighting; and improved tissue culture productivity induced by various stock plant and culture irradiance techniques.

1. *Direct Effects of Light Intensity on Rooting of Cuttings.* Many reports indicate that reducing light intensities under which cuttings are being rooted improves rooting percentage and root quality. Loach and Gay (17) have demonstrated that irradiance levels of 20 and 40 Wm^{-2} were superior to higher levels for rooting *Forsythia* and *Weigela* and they suggest that "light levels in glasshouses are super-optimal for root initiation," and therefore, shading would aid rooting of cuttings through much of the year. Biran and Halevy (4), reported that reducing light intensity by 50% for dahlia stock plants helped improve rootability of cuttings. Cultivars varied in their response to various shading treatments. However, shading only the base of the cuttings improved the rooting percentage and number of roots per cutting. Etiolation has also been used to improve rooting of some difficult-to-root species. A particular-

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ly interesting illustration of such rooting enhancement in avocado was reported by Frolich (9).

2. *Photoperiod Effects on Rooting of Cuttings.* Long-day (18-hr) treatments are stated by Bhella and Roberts (3) to encourage rooting of Douglas fir (*Pseudotsuga menziesii*) and Lanphear and Meahl (16) reported that *Juniperus* cuttings rooted better under long-day (LD) than short-day (SD) regimes. Similar results were stated for *Populus* × *robusta* by Wareing and Smith (25). Nitsch (20) suggested this to be the case for a wide spectrum of woody species and Waxman (26) in 1965 listed similar results for *Cornus florida*.

3. *Effects of Light Intensity on Stock Plants on Rooting of Cuttings.* Hansen (10) is well-known for research with pea cuttings in which he has repeatedly demonstrated that reduced stock plant irradiance levels, as low as 4 Wm^{-2} significantly increased root number per cutting. Similar reports by Anderson and Carpenter (1) with chrysanthemum, Biran and Halevy (4) with dahlia, and Moe (19) with *Campanula* can be noted. Although these researchers worked primarily with herbaceous species, Johnson and Roberts (15) have obtained similar responses by shading *Rhododendron* stock plants. They hypothesized that since lower light levels caused reduced flower formation, the improved rooting may have been related to less competition for materials necessary for rooting.

4. *Influences of Stock Plant Photoperiod.* Direct effects of photoperiod supplied to the stock plant on rooting of cuttings have been demonstrated by Hentig (14) with several herbaceous species and azalea, and by Bachelard and Stowe (2) with *Acer rubrum* and *Eucalyptus camaldulensis*. In most cases, this improvement was a result of LD treatments. Such an effect could, of course, be related in part to increased photosynthesis in the stock plant and thus result in cuttings containing more substances necessary for rooting.

Perhaps a more interesting and potentially useful effect is the use of LD, either by day extension or night interruption, to keep stock plants vegetative during times of the year when they normally would become dormant. Short-days are a major cause of woody plant dormancy, so LD-induced vegetative growth results in a continuance of cutting supply. In 1957, Flint (8) reported such a response with geraniums and chrysanthemums, and Heins *et al.* (11) have also presented similar results for chrysanthemums. Waxman (26) with *Cornus florida*, and Henny and Read (13) with deciduous azaleas, also increased the number of cuttings produced by stock plants subjected to LD treatments. More recently, Economou (7) and Read *et al.* (22) have reported this approach with several woody species for increasing explant material for micropropagation techniques.

5. *Stock Plant Response to Light quality.* Another interesting approach is the use of light *quality* modificatons of the stock plant environment. Heins *et al.*, (11,12) reported that chrysanthemum stock, when given night irradiation with red or incandescent light sources, showed enhanced rootability of cuttings. Stock plant irradiance with red light, followed by incandescent irradiance of the cuttings was the most effective. They also demonstrated an enhancement of number of cuttings produced as a result of stock plant irradiation with red light, which was attributed to increased axillary bud activity.

6. *Light Effects on Success of Micropropagation.* Dunwell and Perry (6) reported that *Nicotiana tabacum* plants grown under 8-hour photoperiod and high light intensities had increased haploid plantlet production. Enhancement of protoplast yield by use of reduced light intensity has also been shown for tomato mesophyll (5). Dunwell and Perry further proposed that, "This may have wider implications in tissue culture . . . endogenous hormone levels could be changed by manipulation of the environment." The concept of influencing tissue culture success by stock plant light quality treatments had been reported by Read *et al* (21) whereby red light applied for 30 minutes at the end of a 10-hour day caused a near doubling of plantlets produced by petunia leaf discs. Tucker (23) had earlier demonstrated that a 5 min daily treatment of tomato plants with far-red light suppressed side shoot development. This was thought to be related to a cytokinin:auxin ratio. This could be related to the observation of Van Staden and Wareing (24) who demonstrated that red light illumination of *Rumex obtusifolius* seeds resulted in an increased amount of extractable cytokinins and that this response could be reversed by immediate application of far-red light. These observations encouraged a further consideration of red light as a factor to enhance microshoot production in tissue culture systems with deciduous azaleas.

MATERIALS AND METHODS

Recultures of Accessions 620014 and 800374 hardy deciduous azaleas (HDA) were used as the stock materials to receive the light treatments. These recultures or microstock cultures (MSC) were produced by harvesting microcuttings from previously cultured HDA shoot tips under conditions described by Read *et al.* (22) and by Economou (7). The resulting tissue was placed on new medium and subjected to various light treatments as follows.

Light intensity experiment: By use of shading material in combination with cool-white fluorescent bulbs, 10, 30 and 75 $\mu Em^{-2}\ s^{-1}$ light intensities were achieved. After culture under these levels for 6 weeks, microcuttings were harvested and direct-rooted in peat:perlite:vermiculite (2:1:1) medium in a humid chamber (R.H. = 90%). Data were taken after 3 weeks on root quality (scale of 1-3, with 3 = best), root length and percent rooting.

Light quality experiment: Monochromatic fluorescent tubes providing red (R) or far-red (FR) (GTE Products, Corp., Sylvania Lighting Center, Danvers, Massachusetts 01923) light were utilized. MSC were placed under red light for 2 weeks followed by far-red light for 2 weeks, or the reverse; microcuttings were rooted as in the light intensity experiment. Data taken included root number, root quality (scale of 1-3), and percent rooting.

RESULTS AND DISCUSSION

Lower light intensity (10 or 30 $\mu Em^{-2}s^{-1}$) proved to be superior to the higher irradiance level for microcutting production (Table 1). The increased root formation and growth is clearly shown in Figure 1. A possible reason for such im-

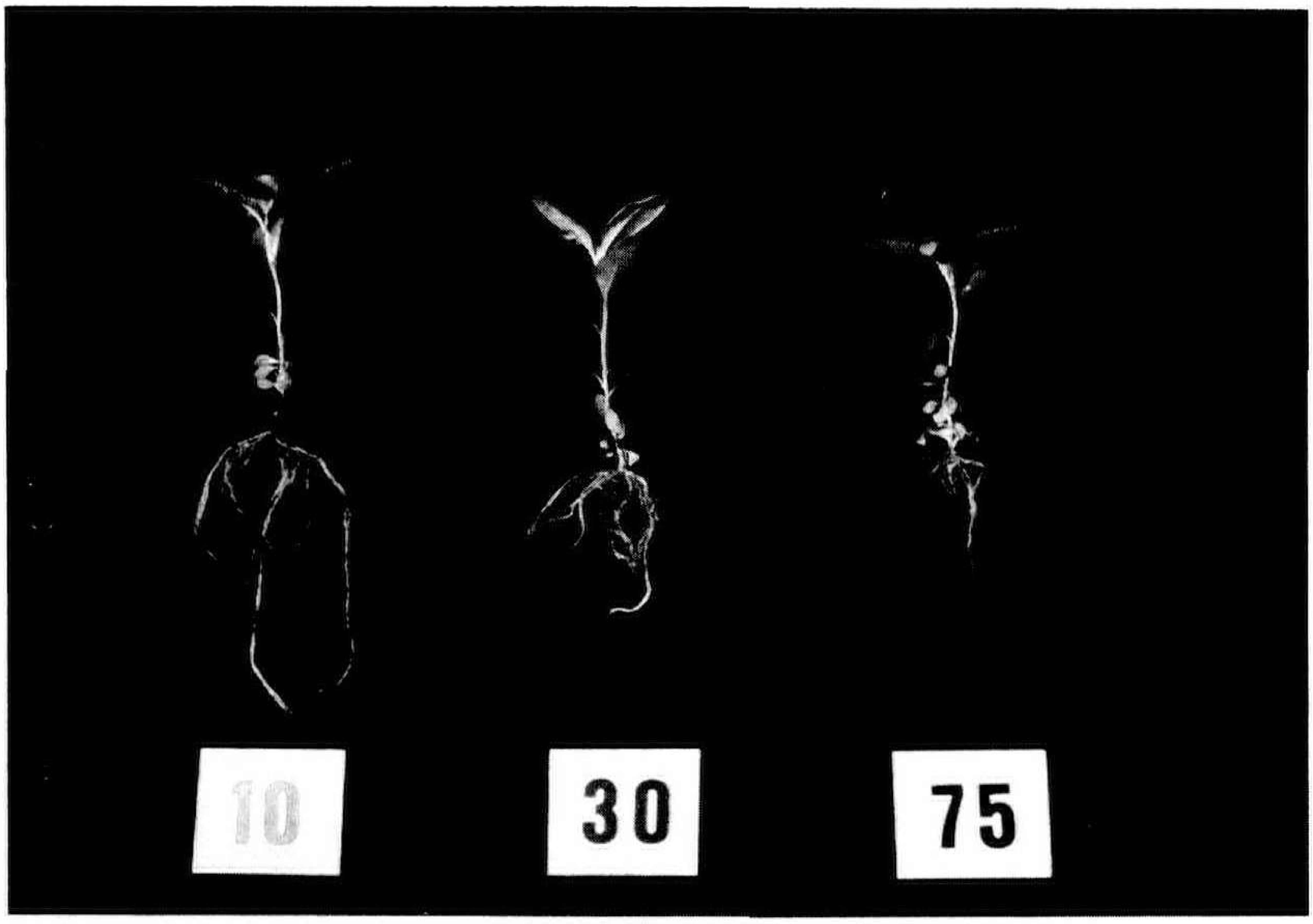

Figure 1. Rooting response of hardy deciduous azalea Accession 800374 microcuttings harvested from recultured *in vitro*-derived shoot cultures which were grown under different quantum flux densities (light levels).

Table 1. Rooting of azalea Accession 800374 microcuttings harvested from recultured *in vitro*-derived shoot cultures which were grown under different quantum flux densities.

Quantum flux density ($\mu Em^{-2}s^{-1}$)	Mean No. of rooted microcuttings[z]	Average percent rooting
10	35.6	88.3
30	32.6	81.7
75	26.3	65.8

[z] All microcuttings rooted under 85 $\mu Em^{-2}s^{-1}$ (400-700nm), 3 replications of 40 microcuttings per treatment, 6 wks in rooting medium.

Table 2. Effect of sequential culturing from different light qualities on microcutting production from recultured *in vitro*-derived shoots of azalea Accessions 620014 and 800374.

	Clone					
	Accession 620014			Accession 800374		
Light treatment[z]	No. of microcuttings	Length (cm)	Quality rating	No. of microcuttings	Length (cm)	Quality rating
red, far-red	61.8b[y]	3.7b	2.4a	49.6b	1.9	2.2a
far-red, red	46.8a	3.5ab	3.0b	30.8a	1.9	2.9b

[z] 24 hrs daily for 2 wks under each light source.

[y] Mean separaton within columns by HSD, 1% level; 10 cultures per treatment.

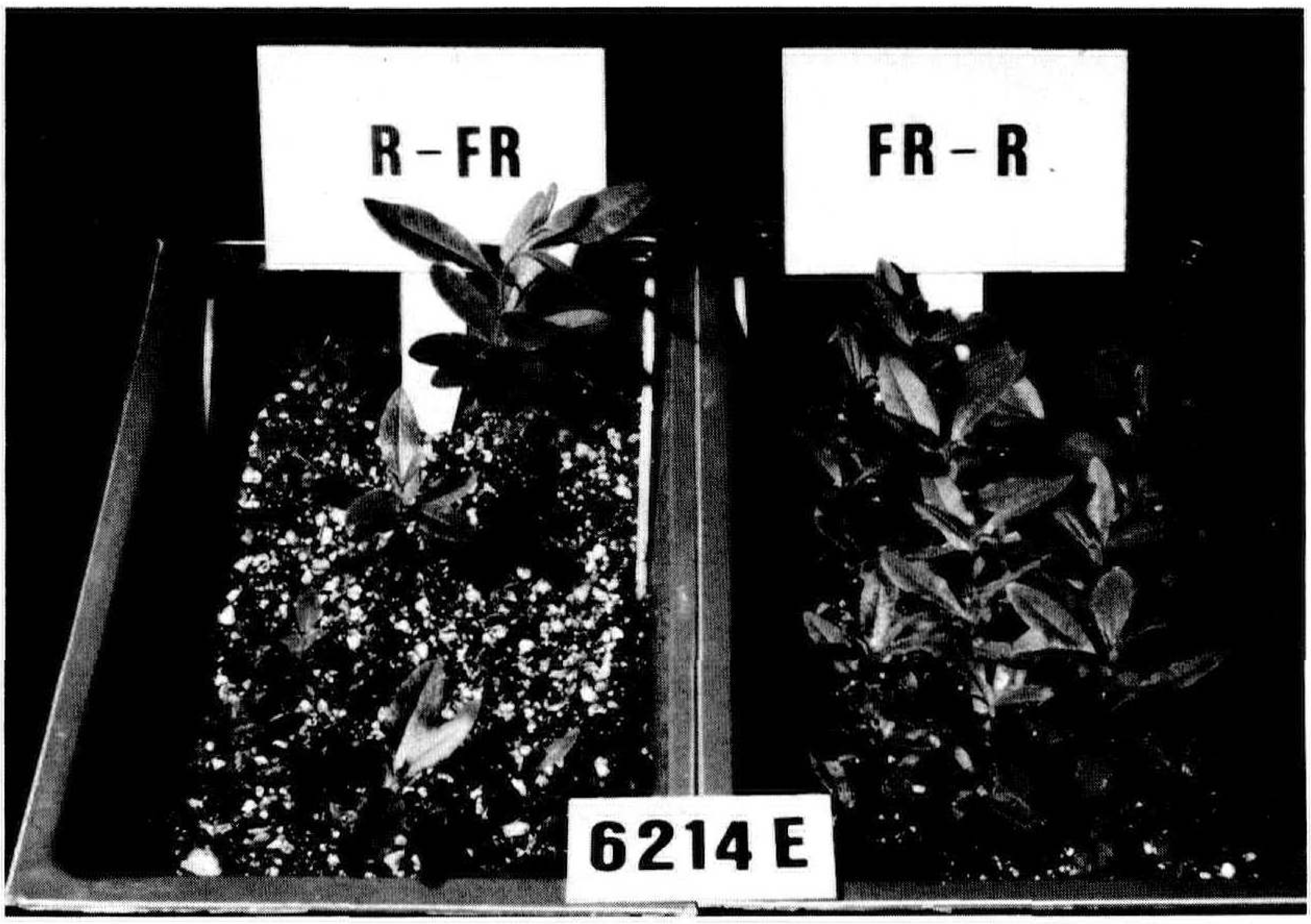

Figure 2. Response of microcuttings taken from cultures receiving different sequences of red (R) and far-red (FR) light.

proved rooting could be that more endogenous root-promoting substances (possibly IAA) accumulate in tissues of MSC which receive low levels of irradiance, since IAA is known to be reduced under high light levels (18). Stock plants grown under two weeks of R following two weeks of FR produced microcuttings with a higher percentage rooting than R followed by FR (Table 2 and Figure 2). Again, such responses are hypothesized to be related to changes in endogenous hormone levels since they are somewhat like those reported for light quality influences on petunia stock plants prior to tissue culture, but more research is necessary to better understand these changes. However, it is clear that light intensity and possibly light quality, can be manipulated by the practical micropropagator of woody plants. It is also recommended that propagators utilize day extension or night interruption to obtain additional softwood growth for use as cuttings or micropropagation explants. Further application of such long-day treatments to cuttings or microcuttings, once rooted, should lead to increased survivability of such propagules.

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