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Influence of Gibberellins$_{4+7}$ on Germination of Fraser Fir[1]

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Abstract

Seeds of Fraser fir [*Abies fraseri* (Pursh) Poir.] were soaked in solutions of gibberellins$_{4+7}$ (GA_{4+7}) at concentrations of 0, 400, 500, 600, 700, 800, 900, and 1000 ppm. Following treatment, seeds were germinated in the presence and absence of light at 9/15 hr thermoperiods of 30°/20°C (86°/68°F) and 20°/10°C (68°/50°F). At 30°/20°C (86°/68°F), 42-day germination of seeds maintained in darkness was significantly increased at GA_{4+7} concentrations of 500 and 600 ppm. Stimulation was not noted for illuminated seeds at 30°/20°C (86°/68°F) or for seeds germinated at 20°/10°C (68°/50°F).

Index words: *Abies fraseri*, gibberellic acid, seed, sexual propagation

Introduction

Fraser fir [*Abies fraseri* (Pursh) Poir.] is a coniferous species indigenous to restricted areas of the Southern Appalachians (10) and is utilized commercially for Christmas trees, landscape purposes and yuletide greenery. Commercial propagation is exclusively by seed and is not without inherent difficulties. Seed production is limited and most seeds are harvested from native stands. Trees do not produce appreciable quantities of viable seeds until at least 20 to 30 years of age and bountiful crops only occur every 3 to 4 years thereafter (7). Germination of the seeds is generally poor and rarely exceeds 55% (4). Germination is not regulated by any rigid internal dormancy and following sowing, may occur within a period of 2 weeks to several months. Overall, germination may best be described as erratic and treatments to enhance germination, both total and rate, would be beneficial.

Stratification (moist-prechilling) of Fraser fir accelerates the rate of germination, broadens the range of temperatures over which germination occurs, and reduces sensitivity of the seeds to light (2). Stratification, however, is time consuming, requires special equipment, and encourages fungal growth which reduces the viability of some seed lots (1). It would be useful if other methods of seed treatment could be developed which would achieve the same results as stratification without decreasing viability. One possibility might involve treatment of seeds prior to sowing with various plant growth regulators. Different formulations of gibberellin have been shown to stimulate germination of numerous species: GA_3 [black walnut (*Juglans nigra* L.) (6), American horn-

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beam (*Carpinus caroliniana* Walt.) (5), silver fir (*Abies alba* Mill.) (9), Douglas fir [*Pseudotsuga menziesii* (Mirb.) Franco] (12) and GA_{4+7} [rabbiteye blueberry (*Vaccinium ashei* Reade. cv. Tifblue)] (3). A preliminary investigation suggested that GA_{4+7} might promote germination of Fraser fir. Thus, the following research was undertaken to examine the influence of GA_{4+7} on germination of the species.

Materials and Methods

Seeds were collected in 1981 by the North Carolina Forest Service from native trees at Roan Mountain [36°01′ N latitude, 82°05′ W longitude, elevation = 1900 m (6234 ft)], dried to a moisture content of 4% to 6% and stored in a polyethylene bag at −17°C (1.4°F). Abnormal, damaged, undersized, or resinous seeds were removed by hand prior to the initiation of the experiment. In February 1986, seeds were removed from storage and graded seeds were soaked for 20 hr with gentle agitation at 25 ±1°C (77 ± 1.8°F) in GA_{4+7} [Provide®, (Abbott Laboratories), 50% GA_4/50% GA_7, 2% w/w] solutions of 400, 500, 600, 700, 800, 900, and 1000 ppm, followed by transfer to 9 cm (3.5 in) covered, glass Petri dishes containing blotters moistened with tap water. Two control treatments (0 ppm) were utilized. One consisted of seeds soaked for 20 hr at 25 ±1°C (77 ±1.8°F) in distilled water (''water control''). The second was dry seeds placed directly on moist blotters (''dry control''). All dishes were placed in black, sateen cloth bags and randomized on metal trays which were placed in two Pfeiffer seed germinators maintained at 9/15 hr thermoperiods of 30°/20°C (86°/68°F) and 20°/10°C (68°/50°F). Temperatures varied within ±1°C (1.8°F) of the set point and relative humidity was approximately 100%.

For a temperature regime, each GA_{4+7} treatment consisted of 12 dishes containing 50 seeds per dish. Half of the dishes within a treatment received a daily 1 hr illumination from cool-white fluorescent lamps during the high temperature portion of the cycle while all other seeds were germinated in constant darkness. Lamps provided a photosynthetic photon flux density (400 to 700 nm) of 24 to 30 μmol $m^{-2}s^{-1}$ (1.8 to 2.2 klx) as measured with a cosine corrected LICOR LI-185 quantum / radiometer / photometer. Because germinators were not equipped with lights, the light treatment was imposed by setting trays on benches adjacent to the germinators.

Germination was recorded every 3 days for 42 days with the criterion for germination radicle emergence >2 mm (0.08 in). For fungal control, seeds were sprayed on days 1, 4, 7, and weekly thereafter with an aqueous suspension of benomyl [(methyl [1-)(butylamino carbonyl[-1H-benzimidazol-2-yl] carbamate] containing 300 mg/l (1). Approximately 0.2 ml of liquid was applied per dish on each occasion. For dark-treated seeds, germination counts and benomyl applications were carried out under a green safelight known not to affect germination. Germination blotters were kept moist with tap water throughout the experiment and seeds exhibiting any signs of decay were immediately removed from the dishes.

Percent germination was calculated as a mean of 6 replications per treatment. Comparison of means was accomplished using the LSD (5%) test. Germination rate was calculated as the average number of days required for radicle emergence within a treatment (8).

Results and Discussion

At 30°/20°C (86°/68°F), GA_{4+7} stimulated germination of seeds maintained in darkness and stimulation at 500 and 600 ppm was statistically significant (LSD 5%) compared to either control (Fig. 1B). Germination of illuminated seed was not significantly enhanced at any GA_{4+7} concentration (Fig. 1A). Data are presented for the two most effective

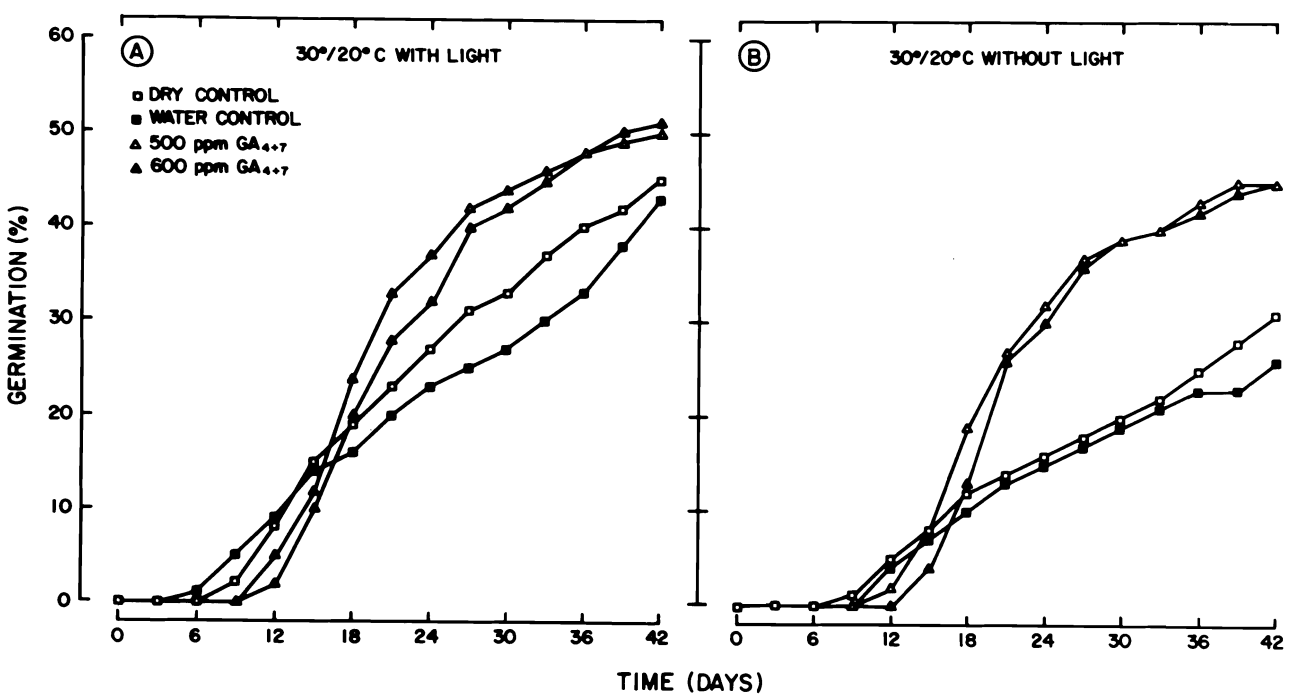

Fig. 1. Influence of GA_{4+7} on seed germination of Fraser fir. (A) germinated at 30°/20°C (86°/68°F) with a 1-hr light treatment during the 9-hr, 30°C (86°F) portion of the cycle; (B) germinated in darkness at 30°/20°C (86°/68°F). Legend in (A) applies to both figures.

GA_{4+7} concentrations for both illuminated and non-illuminated seeds. The onset of germination for the treated seeds was slightly accelerated as the average number of days to radicle emergence was less for the 500 and 600 ppm concentrations than for the controls (23.0 days vs. 24.8 days) (data not presented).

At 20°/10°C (68°/50°F), GA_{4+7} did not promote germination beyond that achieved by the dry control in either light or darkness (Fig. 2). However, after 42 days, germination at 400 and 500 ppm was significantly greater than the water control in both light and darkness. At GA_{4+7} concentrations greater than 500 ppm, germination was less than the dry control and not significantly different from the water control, regardless of illumination. Rate data are not presented since the dry control germinated earlier and more rapidly than any of the GA_{4+7} treatments.

A second experiment tested GA_{4+7} concentrations of 100, 200, and 300 ppm to determine their effect upon germination. Stimulation exceeding that at the higher concentrations was not noted at either thermoperiod (data not presented).

Treating Fraser fir seeds with GA_{4+7} can stimulate 42-day germination at 30°/20°C (86°/68°F) but not at 20°/10° (68°/50°F) (Figs. 1 and 2). Light appears to antagonize the effect of GA_{4+7}. This is most noticeable at 30°/20°C (86°/68°F) but is also present to a lesser degree at 20°/10°C (68°/50°F). As a result, GA_{4+7} treatment is of benefit only when seeds are germinated at a 30°/20°C (86°/68°F) thermoperiod in the dark.

Commercial production of Fraser fir is confined to high-elevation regions of the Southern Appalachians. Seeds are usually sown in early spring, when temperatures are relatively cool. The 20°/10°C (68°/50°F) thermoperiod used in this experiment simulates temperatures normally encountered at spring sowing. As noted in Fig. 2, GA_{4+7} does not increase germination after 42 days or the onset of germination under such conditions and, therefore, would appear to be of little benefit for field production.

Treatment with GA_{4+7}, however, might be beneficial for greenhouse production of seedlings. The warmer temperatures encountered in such an environment would correspond more closely to the 30°/20°C (86°/68°F) thermoperiod used in this experiment (Fig. 1). Such a procedure might be justified if it resulted in more efficient utilization of limited seed supplies presently available. Additional research, however, would be necessary prior to implementation of this procedure since this experiment did not determine the effect of GA_{4+7} treatment on subsequent seedling growth.

Gibberellic acid (GA_3) has been more widely used than GA_{4+7} to stimulate germination of various species. Richardson (12) found that GA_3 accelerates the germination rate of Douglas fir but has no effect on total germination. Pharis and Kuo (11) noted the positive influence of GA_3 on 16 of 23 conifers tested. We tested GA_3 in addition to the GA_{4+7} research reported herein. Studies indicated that GA_3 has no stimulatory effect on germination of Fraser fir.

Our data suggest that Fraser fir germination is inhibited by a water soak prior to sowing. Inhibition is slight when seeds are germinated at 30°/20°C (86°/68°F) (Fig. 1) but increases greatly at 20°/10°C (68°/50°F) (Fig. 2). Perhaps germination could be stimulated at lower temperatures if the inhibition caused by soaking was reduced. One way to counteract this inhibition might be to reduce the soaking time. A shorter soaking period may also further enhance germination at 30°/20°C (86°/68°F). In addition, other methods of GA application, such as vacuum infiltration (6), warrant investigation.

Significance to the Nursery Industry

Seeds of Fraser fir are in great demand but the supply is limited. Therefore, any treatment which enhances germi-

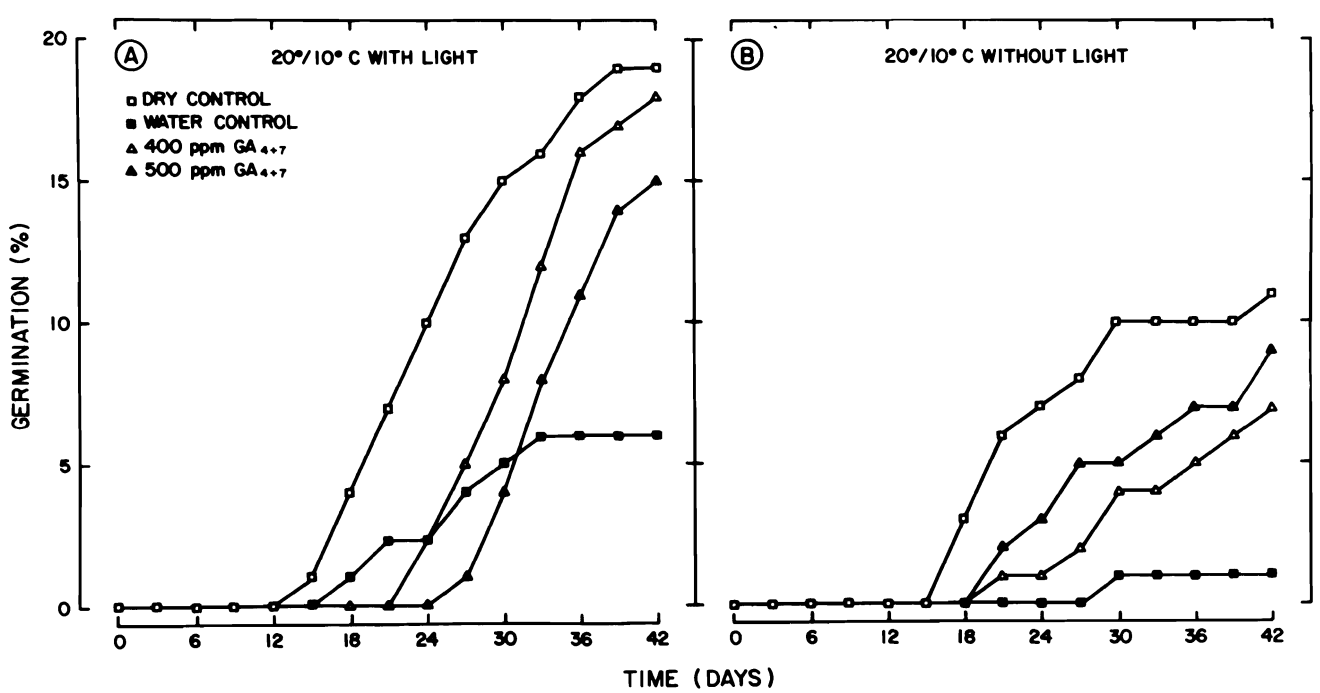

Fig. 2. Influence of GA_{4+7} on seed germination of Fraser fir. (A) germinated at 20°/10°C (68°/50°F) with a 1-hr light treatment during the 9-hr, 20°C (68°F) portion of the cycle; (B) germinated in darkness at 20°/10°C (68°/50°F). Legend in (A) applies to both figures.

nation would result in increased efficiency of seed utilization. Treatment with GA_{4+7} stimulates 42-day germination at 30°/20°C (86°/68°F) but not at the cooler temperatures [20°/10°C (68°/50°F)] similar to those encountered by commercial growers under field conditions. Thus, treatment of seeds with GA_{4+7} appears to have merit primarily for greenhouse production of seedlings.

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Irrigation Frequency and Shading Influences on Water Relations and Growth of Container-Grown *Euonymus japonica* 'Aureo-marginata'[1]

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Abstract

Trickle irrigation frequency, shading, water relations, and plant growth of container-grown *Euonymus japonica* Thunb. 'Aureo-marginata' was investigated. Plants were grown under a combination of 3 irrigation frequencies and 2 shade levels. Stomatal conductance (g_s) was reduced when plants were irrigated 3 times per week compared to irrigation daily and twice daily after week 4 under full sun and after week 8 under shade. Few differences were detected in predawn shoot water potential (Ψ_{shoot}) under shade at any irrigation level. The predawn shoot water potential (Ψ_{shoot}) was reduced (more negative) for plants irrigated 3 times per week compared to irrigation daily and twice daily after week 8 for plants grown under full sun and week 10 for plants grown under shade. These values remained lower for the duration of the study. Plants grown under shade and irrigated once daily had greater plant dry weight and leaf area compared to plants irrigated either twice daily or 3 times per week. They were also larger than all plants grown under full sun. Plants grown under shade had greater chlorophyll levels per unit leaf area. Under shade, plant quality was not affected by irrigation rates. However, only plants grown under shade were of salable quality.

Index words: water potential, stomatal conductance, environmental stress

Introduction

Many woody landscape species are almost entirely produced in containers. Most growers use soilless mixes that require a consistent source of nutrients appropriately balanced and careful water management. Many container-grown woody species require shading and additional irrigation during the summer months when the afternoon temperatures exceed 35°C (95°F) (4). Elevated root-zone temperatures are also a problem. The root-zone in exposed containers can reach temperatures as high as 50°C (122°F) (6, 8, 9, 14). Therefore, species with especially sensitive root systems must be produced under shade or the root-zones must be protected until the plant canopy provides shade (6, 8). Plants produced under shade require modifications in management

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