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Effects of Irrigation Systems, Gibberellic Acid, and Photoperiod on Seed Germination of *Kalmia latifolia* L. and *Rhododendron maximum* L.[1]

Patricia J. Duncan[2] and T. E. Bilderback[3]
Department of Horticultural Science, North Carolina State University, Raleigh, NC 27650

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Abstract. **Freshly harvested, unstratified seeds of *K. latifolia* and *R. maximum* were treated with GA_3 for 36 hours at concentrations of 0, 50, 200, and 1000 ppm, sown in multicell flats containing 3 bark: 1 sand medium (v/v), grown for 21 days in a greenhouse under 10-hour and 24-hour photoperiods and irrigated by mat, intermittent mist, or hand-sprinkling. Average germination was 79.8% for *K. latifolia* and 79.2% for *R. maximum*. Seed germination of *K. latifolia* was 90% under intermittent mist and 24-hour photoperiods. *R. maximum* germination was highest under intermittent mist watering (88%) with no difference between 10-hour and 24-hour photoperiods. Gibberellic acid (GA_3) treatment had no effect on germination in either species.**

Media for seed propagation of Ericaceous plants have been composed predominantly of ground European sphagnum peatmoss or Canadian sphagnum peatmoss or have been combined with other components such as vermiculite, perlite, sand, or soil (5, 6, 9). However, a medium composed predominantly of peatmoss may retain excess moisture, which can result in algal growth and ammonium toxicity at cool temperatures (7). Pine bark contains great numbers of macropores which drain freely and a medium containing pine bark does not remain saturated.

Methods for promoting germination in woody plants include stratification, exposure of seed to varying light sources or intensity, and chemical stimulations (1, 2, 3, 4, 7, 8). Fresh *Kalmia latifolia* seed germinate without special treatment, but germination percentage and uniformity of emergence may be increased with cold stratification or GA_3 treatment (7, 9). Jaynes (7) has reported that 200 ppm GA_3 breaks seed dormancy of *K. latifolia*.

Light is required for germination of *K. latifolia* seed and a 16-hr daily photoperiod with 50 $\mu E\ m^{-2}\ s^{-1}$ has been suggested to increase germination (7), but there is very little experimental information on germination of *Rhododendron maximum* (9).

The objective of this study was to determine the effects of 3 watering systems on a pine bark and sand medium, GA_3 application, and 2 photoperiods on seed germination of *K. latifolia* and *R. maximum*.

Open-pollinated seeds were collected from plants when capsules began to dehisce. *R. maximum* seed were collected on Nov. 7, 1978, and *K. latifolia* seed were collected on Dec. 5, 1978, from a native stand in Watauga County, N.C. Seed were cleaned and divided into groups of 100 and stored dry at 21°C until pregermination treatment began. On December 14, seed surface was sterilized with 0.2% sodium hypochlorite for 10 min, rinsed with distilled water, and randomly divided into groups for treatment with GA_3 (Pro-Gibb, Amdal Corp., Abbott Laboratories, 2% GA) at either 0, 50, 200, or 1000 ppm. After a 36-hr soak at room temperature, seed were placed on filter paper, rinsed with distilled water, and divided into groups of 5 for sowing. At no time did the seed undergo artificial stratification and seed were sown immediately after the GA_3 treatment.

Plastic flats with 32 subdivided insert cells measuring 6 × 6 × 5 depth were filled with a medium composed of 3 parts screened pine bark (passed through 6.2-mm screen) and 1 part coarse sand medium (v/v), amended with dolomitic lime at 1.4 kg per m^3 to adjust pH to about 5.0, and steam-pasteurized. Five seeds were sown per cell. A split-split plot design was used with each GA_3 treatment replicated 4 times per flat and 4 replications per photoperiod and watering system. A total of 480 seeds per species were included in the study.

Hand-watered flats were placed on a wire bench and watered twice daily. Mist irrigation treatments were placed in a pasteurized sand bed and misted 6 sec every 6 min from 0730 to 1630 HR. A composition mat underlined with polyethylene was used for subirrigation. The mat was flooded with water twice daily. During the germination period, temperatures ranged from 17 to 27°C (day) and 16° (night).

Supplemental light for the 24-hr photoperiod treatment was provided by 100-watt incandescent bulbs placed 60 cm above the flats. Irradience at the media surface ranged from 11 $\mu E\ m^{-2}s^{-1}$ (400–700 nm) (480 lux) in the center of the bench to 5 $\mu E\ m^{-2}s^{-1}$ (190 lux) at the edges. Radiant power density ranged from 1.39 to 0.57 Wm^{-2} (760–830 nm). The 10-hr photoperiods were obtained with black cloth.

Benlate (benomil) was applied to the seedling flat 10 days after sowing to reduce damping-off. Germinated seeds were counted 21 days after sowing.

Germination of *K. latifolia* was significantly increased by the 24-hr photoperiod, as reported by Jaynes (6, 7) (Table 1). Germination was 74% under 10-hr photoperiod and 86% under continuous lighting. Seed germination of *R. maximum* was unaffected by photoperiod and germination was 76% and 78% for short and continuous lighting, respectively. Seedlings of both species appeared to be slightly more vigorous under continuous lighting than those under 10-hr days.

GA treatment had no effect on germination percentages, but the excessive stem elongation in Kalmia observed by Jaynes (6) was not observed.

Irrigation system affected germination of both species (Table 1). Significantly higher percentages of germination of *K. latifolia* was obtained under intermittent mist watering, with mat watering being intermediate, and hand-watering significantly lower. The most uni-

Table 1. Influence of irrigation system and photoperiod on seed germination of *Rhododendron maximum* and *Kalmia latifolia*.

Treatment	Germination (%)	
	R. maximum	*K. latifolia*
Irrigation[z]		
Intermittent mist	85 a[x]	88 a
Mat	77 b	71 c
Hand	69 c	81 b
Photoperiod[y]		
10 hr	74 a	76 a
24 hr	86 b	78 a

[z]Combined means for seed treated with GA_3 and germinated with 10-hr or 24-hr photoperiods. Each value represents germination percentage of 160 seeds.
[y]Combined means for seed treated with GA_3 and germinated by 1 of 3 irrigation systems. Each value represents the germination percentage of 240 seeds.
[x]Mean separation, within columns and treatments, by Duncan's multiple range test, 5% level.

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[2]Graduate Student, present address: The Ohio State University, 2001 Fyffe Court, Columbus, OH 43210.
[3]Associate Professor, Department of Horticultural Science.

form seedling growth for both species was in the intermittent mist treatment.

Seed germination of *K. latifolia* was highest (90%) in the treatment employing intermittent mist and 24-hr photoperiod. *R. maximum* germination was highest with intermittent mist watering, with no difference between 10-hr (85%) and 24-hr (86%) photoperiods.

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Growth of *Juniperus chinensis* var. *sargentii* as Influenced by Vesicular-arbuscular Mycorrhizae and Soil Fertility[1]

R. W. Roncadori[2] and F. A. Pokorny[3]

University of Georgia, Athens, GA 30602

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Abstract. **Total fresh weight and crown spread of *Juniperus chinensis* var. *sargentii* Henry plants, grown in microplots containing a low fertility medium of 4 soil:1 sand:1 milled pine bark and amended with 10N–4.4P–8.3K fertilizer at rates of 0, 110, or 220 µg/g, were significantly increased by inoculation with a spore mixture of 3 different vesicular-arbuscular (VA) mycorrhizal fungi. Higher fertilizer concentrations improved crown spread but did not affect plant growth. Root colonization by the endophytes ranged from 24.4 to 39.2% and was unaffected by fertilization rates.**

An understanding of the role that VA mycorrhizae play in plant health has led to attempts to manipulate the symbiotic relationship to improve certain crop management systems, such as tree nurseries (12). VA mycorrhizae are involved in mineral absorption (4), primarily phosphorus, and may improve water uptake (4) and transplantability (6, 8, 9, 10). Most reports of plant growth stimulation by VA mycorrhizae have resulted from pot studies using low P soils that are usually treated to eliminate the native microflora (4). Since soil mixes and various potting media used in container production of ornamental plants are often fumigated or treated, these systems offer an excellent opportunity to introduce inoculum and utilize the benefits of VA mycorrhizal fungi (8).

Potential use of VA mycorrhizae has been demonstrated with such crops as poinsettia (1), viburnum, podocarpus and pittosporum (3), rhododendron (7), and magnolia (9). An experiment was designed to evaluate the effects of inoculation with VA mycorrhizal fungi and application of various fertilization rates on root colonization by the endophytes and subsequent growth of *Juniperus chinensis* var. *sargentii*.

On July 23, 1976, 4-month-old, heavily rooted cuttings of *J. chinensis* var. *sargentii* were planted directly into microplots containing a mix of 4 parts forest clay loam soil, 1 part washed river sand, and 1 part milled pine bark (v/v/v). Prior to mixing, soil analysis results as determined by the Soil and Plant Analysis Laboratory, Cooperative Extension Service, University of Georgia, were: P 10, K 30, Ca 144, Mg 20, Zn 2, Mn 60, B 0.5, and NO_3-N 7 µg/g, 5×10^{-5} mhos soluble salts, pH 5.7, and 2.1% organic matter.

During medium mixing, differential fertilization treatments were established by incorporation of a 10N–4.4P–8.3K fertilizer at the rates of 0, 110, or 220 µg/g of mix. The media were fumigated under a polyethylene cover for 48 hr with methyl bromide (Dowfume MC-2), vented, and placed in outdoor microplots. The soil on which the microplots were placed was first drenched with 200 µg/ml (pentachloronitrobenzene) Terraclor and covered with black polyethylene to suppress contamination by the native VA mycorrhizal fungi. The microplots were constructed of 5 × 30-cm lumber with outside dimensions of 61 cm length, 91 cm width, and 30 cm depth, and were spaced 1.2 m apart within and between rows. The interior of each microplot was treated with a 25% NaClO drench and each unit received 0.17 m^3 of medium.

VA mycorrhizal fungi were increased on *Sorghum bicolor* (L.) Moench. 'Shallu' grown in greenhouse pot culture. Spores of *Glomus fasciculatum* (Thaxt. sensu Gerd.) Gerd. & Trappe, *G. mosseae* (Nicol. & Gerd.) Gerd. & Trappe, and *Gigaspora margarita* Becker & Hall were extracted using a modified centrifugal-flotation technique (5). At planting, each microplot received 1 juniper cutting, the root system of which was drenched with a suspension of 4450 spores in 100 ml of water comprised of the following ratio: *G. fasciculatum* (3500), *G. margarita* (600), and *G. mosseae* (350). A mixed spore suspension was used to increase the possibility of development of mycorrhizae, since little is known about fungal symbionts that success fully colonize juniper roots. Each control cutting received 100 ml of spore filtrate collected after passage through Whatman #1 filter paper.

After planting, cuttings were covered with polypropylene shade cloth to reduce light intensity 30%. All plants were irrigated as needed and were fertilized twice during the fall of 1976 with 20N–8.8P–16.6K liquid fertilizer containing micronutrients with each plant receiving 200 µg/g of mix. On May 17, 1977, all plants were fertilized with NH_4NO_3 at the rate of 79 µg/g of mix. In October 1977, plants were harvested and horizontal crown spread and total plant fresh weight were determined. Young feeder roots were collected at random throughout the root system and were assayed for mycorrhizae by clearing and staining (2). The percentage of colonization was determined by measuring the length of root containing mycorrhizae in 20 sections per plant, each 1.5-cm-long. The experiment was a 2 × 3 factorial in a randomized complete block design with 6 replications.

VA mycorrhizae significantly increased both plant fresh weight and crown spread, whereas additional fertilization of 110 or 220 µg/g of mix improved only crown spread by 25–28% (Table 1). VA mycorrhizae increased plant weight by 112–172% and crown spread by 26–54% when compared with nonmycorrhi-

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[2]Professor, Department of Plant Pathology.

[3]Professor, Department of Horticulture.