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Influence of Temperature and Daylength on Growth and Flower Yield of *Anigozanthos manglesii* D. Don (*Haemodoraceae*)

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Abstract. **Seedlings of *Anigozanthos manglesii* D. Don responded positively to watering and fertilization when the night temperature was 12° to 15°C; at higher temperatures, these factors caused seedling death. Cold treatment (10°C for 17 hours a day for a month) of seedlings prior to planting stimulated growth, new fan production, and flower yield. Temperatures below 10° promoted flower differentiation, whereas cultivation at higher temperatures reduced flower yield. Illuminating plants at night from 2200 to 0200 HR did not affect flower yield when plants were grown at relatively low temperatures, but it did reduce yields when they were grown in a heated greenhouse.**

Anigozanthos manglesii (Haemodoraceae) is an endemic Western Australian plant commonly known as the kangaroo-paw. It grows in a Mediterranean climate (no summer rainfall) under light shade and in well-drained soils (2, 3, 4, 5). Most growth is during the winter months; in the summer the plant is dormant (1) and sensitive to over-irrigation and fertilization (7). The plant was introduced into Israel about 6 years ago for cultivation for cut flowers.

Since there was no information available about temperature requirements of this crop, this work was designed to study the effects of temperature and daylength on both young seedlings and growing plants in terms of plant growth (plant height and number of fans), flower yield, and timing.

Anigozanthos seeds were sown in a 1 fine tuff (0–3 mm) : 1 peatmoss mixture. A month after sowing, seedlings were potted in a 4 tuff : 1 peatmoss medium in 7 × 7 × 8 cm plastic pots and were grown for a further month. The effect of temperature on growth was examined in temperature-controlled greenhouses under natural daylength (12 hr) with 12-hr thermoperiods of 20°/12°C, 27°/17°, and 35°/25°. Plants were drip-irrigated once a day for 5 min until drainage water appeared. Osmocote 15N–6P–12K (3 g/pot) was applied at the beginning of the experiment. Plant height and the number of fans were measured at the begining of the experiment and 2 months later.

The 20°/12°C regime gave the best results; all seedlings remained green and some developed new fans (Fig. 1). At higher temperatures (35°/25°) all seedlings collapsed. At 27°/17°, about half of the seedlings survived, but these were in poor condition. Low night temperature was found to be important for seedling growth.

Two-month-old *Anigozanthos* seedlings were divided into 2 groups of 45 seedlings each to determine the effect of cooling seedlings before planting. Prior to placement in a screenhouse, one group was held for one month (Sept. 10 to Oct. 10) from 1400 until 0700 HR at 10°C and during the day in an 80% shade screenhouse where the average temperature was 25°. The 2nd group remained in the screenhouse throughout the whole period. The height of the plants and the number of fans were measured 3 times: 3 weeks after planting, 2 months later, and 3 months later. The number of flower-bearing stalks was counted at flowering time.

Seedlings that were placed in a cold room prior to planting developed faster than the screenhouse-grown seedlings (Fig. 2). After receiving sufficient natural cooling, screenhouse-grown seedlings started to develop new fans one month after the cold-treated plants. In February (about the time of flower differentiation) there was an average of 10.6 ± 0.5 fans in the cold-treated plants and 8.3 ± 0.4 in the untreated plants. The first flowers appeared at the beginning of April and the last at the beginning of June. Treated seedlings produced an average of 5.5 flowers/plant; control plants produced only 3.0.

Two-month-old *Anigozanthos* seedlings were planted in spring (May 31, 1981) in a 30% shade screenhouse and in autumn (Oct. 15, 1981) in a heated (18°C night) or unheated greenhouse to determine the effects of temperature and daylength on growth and flower formation.

Plants were grown at 30 × 30 cm in raised benches containing 20 cm of tuff (0–8 mm diameter) and irrigated twice a week for 1 hr through a dripper delivering 2 liters/hr of water containing 20N–9P–17K fertilizer at a rate of 80 ppm N.

Two daylength treatments were given starting on Dec. 5, 1981: natural daylength (10 hr) and natural daylength supplemented with a 4-hr night break (2200–0200 HR) provided by 200w incandescent lamps placed 2 m apart, 1 m above plant height. On Feb. 9, 1982, plant height, fan number, and the number of flower-bearing stalks were determined.

Average minimum and maximum temperatures prevailing in the screenhouse and the 2 greenhouses are shown in Fig. 3. Four months after planting, plants growing in the unheated greenhouse proliferated more fans than those growing in the heated one. Supplementary light did not affect the number of fans per plant in the unheated greenhouse; however, in the heated greenhouse, supplementary light increased the number of fans produced but reduced fan height (Table 1).

The average number of flower stalks per plant was about 9 in the screenhouse under natural and long-day conditions, as well as in the unheated greenhouse under natural daylength. Supplementary light reduced the number of flowers per plant in the unheated greenhouse. In the heated greenhouse, flower

Table 1. The influence of temperature and daylength on fan development and flower yield in 4-month-old *Anigozanthos* plants.

Growth conditions	No. plants	Avg fan height (cm)	Avg no. fans/plant	Avg no. flowers/plant
Screenhouse				
Natural Daylength	139	---	---	9.2
Long Day	138	---	---	9.2
Unheated Greenhouse				
Natural Daylength	95	29.5 ± 0.6	11.7 ± 0.4	9.2
Long Day	106	26.6 ± 0.6	11.6 ± 0.4	8.0
Heated Greenhouse[z]				
Natural Daylength	106	37.7 ± 0.6	5.9 ± 0.1	7.4
Long Day	101	26.4 ± 0.6	8.0 ± 0.3	3.9

[z]18°C at night.

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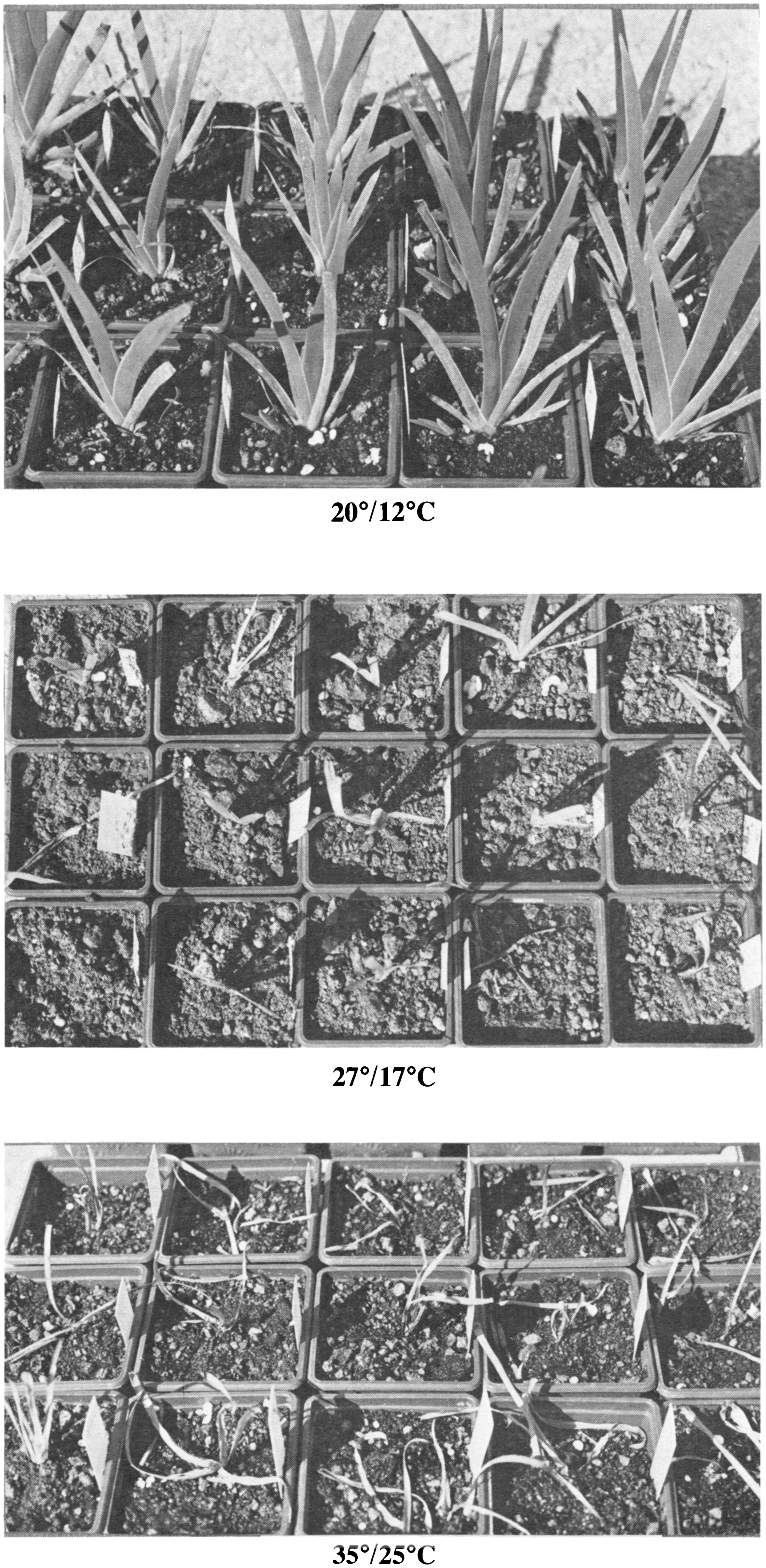

Fig. 1. The effect of day/night temperature regime on the growth of *Anigozanthos* seedlings after 2 months in the growth chambers.

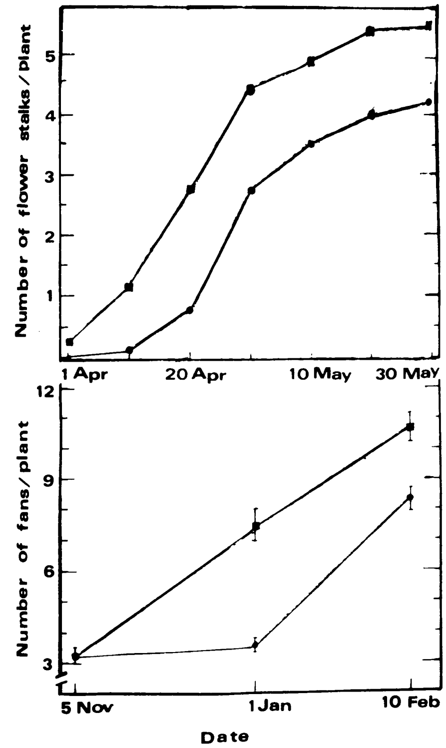

Fig. 2. The effect of precooling *Anigozanthos* seedlings on growth and flower production. The seedlings (■) were planted on Oct. 10 after half of them had been precooled at 10°C by night (25° by day) for one month. The control seedlings (●) were kept at 25° day and night.

yields were considerably lower, especially under long-day conditions.

These results correlate with those obtained for growth rate: with fewer fans there were fewer flowers. There was one exception: in the heated greenhouse under long-day conditions, there were many fans (8 per plant) but few flowers (Table 1). These plants, which grew under artificially heated conditions, apparently did not receive sufficient cold to initiate flowers. Addition of light under the low-temperature conditions of the screenhouse did not affect flower yield.

Daylength had no effect on flower production in the screenhouse, a finding confirming those of Van der Krogt (6). Long-day conditions given during winter reduced flower production of plants growing in a heated greenhouse or in an unheated greenhouse that accumulated heat during the day. Such conditions are similar to those prevailing in summer under which the plant is almost dormant.

Anigozanthos is a typical Mediterranean climate plant: it initiates growth and responds to water and fertilization when night temperatures drop to 12° to 15°C. Planting out *Anigozanthos* seedlings when temperatures are high leads to plant death. Planting should be done in spring or autumn. Precooling seedlings induced root activity immediately upon planting, whereas seedlings which did not undergo this treatment were activated only when the ambient temperatures dropped. Cold-treated seedlings produced more fans and more flowers than did the control plants. When temperatures dropped below 10° at night, ter-

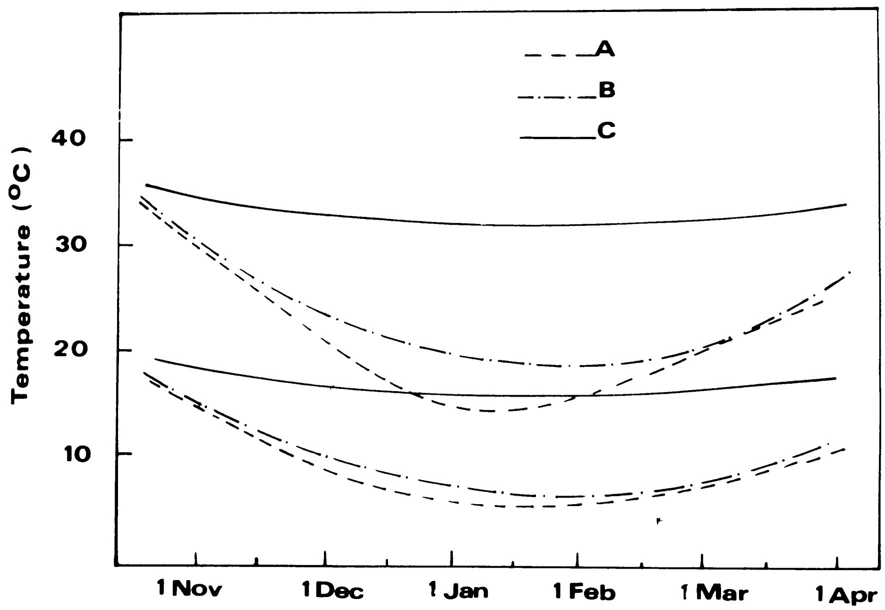

Fig. 3. The average minimum and maximum temperatures (ranges) existing at different dates in the 3 different structures in which *Anigozanthos manglesii* was grown: screenhouse (A); unheated greenhouse (B); heated greenhouse (C).

minal meristems differentiated flowers, and plant resources were directed to flower production.

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Effect of H_2SO_4 and GA_3 on Seed Germination of *Zamia furfuracea*

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Abstract. **Seeds of *Zamia furfuracea* Ait. (cardboard plant) were treated following removal of the sarcotesta (fleshy seed coat) with concentrated H_2SO_4 and 1000 ppm GA_3 in a 4 × 4 factorial combination. The highest total germination of 82.2% in an average time of 74.5 days (germination value = 0.070) was achieved when seeds were exposed to H_2SO_4 for 15 minutes. Average number of days to germination was reduced to 37.7 when 30 minutes of H_2SO_4 treatment was followed by 24-hour GA_3 soak without significantly affecting percent germination (germination value = 0.103). Interactions of H_2SO_4 and GA_3 are explained by the effect of H_2SO_4 on sclerotesta (stony seed coat) thickness and the effect of GA_3 on the accelerated development of an immature embryo.**

Zamia furfuracea Ait., Zamiaceae, is much in demand for subtropical landscapes. It is also one of the most attractive and adaptable of foliage plants for indoor use where there is sufficient light, a fact which is true for other *Zamia* spp. However, slow and erratic seed germination and long production time lead to prohibitive market prices. Smith (9) reported 13% germination of *Z. furfuracea* in 9 weeks and 73% in 25 weeks under laboratory conditions, when both chalazal and micropylar ends of the seeds were cut, while no germination occurred in untreated controls. In greenhouse trials, 72% of the seeds germinated in 28 weeks, when the chalazal end was cut and the outer fleshy coat (sarcotesta) was removed. It is noteworthy that no germination occurred in treated seeds for the first 20 weeks, and untreated seeds had not germinated after 28 weeks. The objective of the present research was to improve the speed and percent germination by rapid scarification of the sclerotesta (stony seed coat) with H_2SO_4 and to accelerate the development of the embryo by the application of GA_3.

Seeds of *Z. furfuracea* were collected from cultivated plants in Miami, Fla. The sarcotesta was removed using a method described by Dehgan & Johnson (3). The seeds were divided subsequently into lots of 90 each in a 4 × 4 factorial experiment with treatments of concentrated (18 M) H_2SO_4 and 1000 ppm GA_3. The H_2SO_4 treatments included a control, 15, 30, and 60 min soak followed by water rinse. The GA_3 treatments were a control, 24, 48, and 72 hr soak prior to planting on the surface of a medium consisting of 1 sand (0.85 mm) : 1 vermiculite. The seeds were planted 15 per container for each of 6 replications per treatment and placed randomly under 30-min-interval intermittent mist. Number of germinated seeds were determined daily, based upon appearance of the coleorhiza, from which the radicle emerges. A Manostat caliper was used to measure the stony seed coat (sclerotesta) thickness at the micropylar end in randomly selected fresh seeds. Germination value (GV), which combines speed and total germination, was calculated using Czabator's (2) method. These were fitted to a full quadratic model with multiple linear regression (1,8). A 3-dimensional plot of the response surface is presented in Fig. 1.

Highest germination (82.2%) occurred with 15 min of H_2SO_4 treatment alone in an average of 74.5 days (GV = 0.070). This time was reduced to 52.7 days when the 15 min H_2SO_4 treatment was followed by 24-hr GA_3 soak without significantly affecting germination (68.9%, GV = 0.073). When seeds were treated with 30-min H_2SO_4 and 24-hr GA_3, however, average days to germination decreased significantly to 37.7 (GV = 0.10).

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