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Cultural Studies in Ornamental Ginger

Jeff S. Kuehny, Mauricio J. Sarmiento, and Patricia C. Branch

INTRODUCTION

Hedychium species (butterfly ginger) and *Alpinia zerumbet* (shell ginger) have been grown in the Southern United States since at least the turn of the century (Burch 1998). *Curcuma* and *Kaempferia* are two other genera in the Zingiberaceae family that have recently gained much notoriety. *Kaempferia* species have unique foliage and *Curcuma* species colorful, long-lasting inflorescences, both with a 90- to 100-day production cycle and few pest problems. These gingers have great potential for use as flowering pot plants, both indoors and as patio and landscape plants. They are herbaceous perennials with short fleshy rhizomes and tuberous roots, often with a dormancy period (Burch et al. 1987). Inflorescence stalks arise either from a short pseudostem or independently from buds on the rhizome. The inflorescence of *Curcuma* species are a compressed spike of colorful long lasting bracts subtending 2 to 7 true flowers (Luc-Cayo and Fereol 1997). *Kaempferia* species, however, have short lived flowers with attractive, colored/patterned leaves that vary in size and shape. Burch (1998) reported that between 150,000 to 250,000 rhizomes of ginger would be sold in 1998. Because of the new genera of ginger continuing to enter the market, the value of ornamental ginger has not been well documented. The number of rhizomes sold has probably doubled (E. Welch, pers. commun.) since 1998 and this does not account for number of plants sold from tissue culture.

There is little information on the optimum production environment, postproduction longevity, and landscape survivability of commercially available gingers. The objectives of this research were to determine the effects of light intensity, photoperiod, and plant growth regulator application on various cultures of *Curcuma* and *Kaempferia* species (Fig. 1–5).

METHODOLOGY

All plants were grown in the greenhouse using a medium consisting of 1/2 peat moss, 1/3 pine bark, and 1/6 perlite, amended with dolomite limestone (5.1 kg/m^3) and superphosphate 0–18–0 (2.7 kg/m^3). Immediately after planting containers were drenched with a tank mix of metalaxyl (Subdue 2E, Novartis, Greensboro, North Carolina) at 15.6 ml/100 L and PCNB quintozene (Terraclor 75% WP, Uniroyal Chemical, Middlebury, Connecticut). Plants were spaced on 21 × 21 cm centers and fertigated with 24N–3.5P–13.3K (Peters 24–8–16 Tropical Foliage, Scotts-Sierra, Marysville, Ohio) at

Fig. 1. *Curcuma alismatifolia* 'Chiang Mai Pink'

Fig. 2. *Curcuma* spp. 'Precious Petuma'

Fig. 3. *Curcuma cordata.*

Fig. 4. *Curcuma petiolata.*

Fig. 5. *Kaempferia* spp. 'Grande'.

150 ppm N as needed.

Data was analyzed using PROC GLM. Comparisons between means was conducted by Tukey's studentized range test.

Light Levels and Plant Growth Retardants

Curcuma spp. 'Precious Petuma', *C. parviflora* 'White Angel', and *C. alismatifolia* 'Chiang Mai Pink' rhizomes were planted one per 14 cm container on 4 April 2000. Plants were grown in a greenhouse at temperature setpoints of 27°/21°C day/night. When shoot height was 10 cm, the plants were drenched with 118 ml of paclobutrazol or uniconazole at 0, 10 or 20 mg a.i. per container and grown under a 0% (1,860 µmol/s/m^2), 30% (922 µmol/s/m^2) or 60% (352 µmol/s/m^2) shade. Average daily temperatures for the three light levels were 30°C. Days to emergence, days to bloom, number of flowers, height of the flowering stalk, and days to anthesis (postproduction longevity) were determined for all plants.

There was no significant effect of shade level on days to emergence or days from emergence to first flower for *Curcuma* spp. 'Precious Petuma'. Flower height was 22% taller for those plants grown under both shade levels. Application of paclobutrazol and uniconazole at 20 mg a.i./pot reduced the flower height of 'Precious Petuma' by 27% and 54% respectively. Because flower height was acceptable (approximately 25 cm) at all shade levels, the use of a growth retardant is not recommended. Shade level had no affect on flower longevity, with an average 29 day postproduction longevity. The number of days from first flower to second flower were extended by approximately 12 days when plants were grown under 60% shade.

Days from emergence to first flower of *C. parviflora* 'White Angel' was significantly extended by approximately 13 days when grown under 60% shade. Flower height was 23% taller at 30% shade; however, due to the short stem of this flower, this height was still acceptable (less than 25 cm). Thus, the use of a growth retardant is unnecessary. Shade level did not affect flower longevity or days to second flower. Flower longevity was favorable at approximately 30 days and days to second flower was approximately 40 days for all treatments.

Days from planting to emergence and emergence to first flower of *C. alismatifolia* 'Chiang Mai Pink' were unaffected by shade level or rate of growth retardant. Days from first flower to second flower was significantly extended by both shade levels with no second flower produced at 60% shade. Thus, these plants must be grown under full sun for best quality. When grown at 30% or 60% shade, flower height was significantly taller by 9 and 13 cm respectively. The flower height of these plants, regardless of shade treatment, was not of marketable quality. The results from this study indicate that for production of a marketable flowering 'Chiang Mai Pink' ginger, application of uniconazole at 10 mg a.i./pot and a rate greater than 20 mg a.i./pot of paclobutrazol is recommended. Postproduction longevity of this ginger is approximately 40 days.

Gibberellic Acid

Curcuma alismatifolia 'Chiang Mai Pink', *C. gracillima* 'Violet', and *C. thorelii* one cm rhizomes were planted one per 14 cm container on 17 April 1999. Prior to planting, rhizomes were soaked for 10 min in a solution containing 2% GA_{4+7} (Provide, Abbot Labs, North Chicago, Illinois) at 0, 200, 400, or 600 mg/L, 10% Physan 20 (10% dimethyl benzyl ammonium chloride, 10% dimethyl ethyl ammonium chloride, 80% inert, Maril Products, Tustin, California) and distilled water. Rhizomes were dried and planted in a greenhouse with average minimum and maximum temperatures of 23° and 30°C night/day. Treatments were arranged in a complete randomized design.

Plants were harvested once a week when they reached a stage characterized by the opening of the last bract and one flower (marketable stage). Days to bloom, number of flowers, and height of the flowering stalk were recorded for all plants.

GA at 200, 400, and 600 ppm delayed shoot emergence of *C. alismatifolia* 'Chiang Mai Pink' (Table 1). GA at 400 ppm delayed flowering but did not increase the number of inflorescences. All plants had one inflorescence per container. Application of GA at 600 ppm reduced flower height (data not shown). GA concentrations of 600 ppm delayed shoot emergence of *C. gracillima* 'Violet' and *C. thorelii* (Table 1). Days to bloom and flower height was unaffected for either *Curcuma*, and plants developed no more than one flowering stem.

Table 1. Effect of gibberellic acid (GA) on days to emergence and days to bloom of *Curcuma alismatifolia* 'Chiang Mai Pink', *C. gracillima* 'Violet', and *C. thorelii*.

	Days to emergence			Days to bloom		
GA (ppm)	*Curcuma alismatifolia*	*Curcuma gracillima*	*Curcuma thorelii*	*Curcuma alismatifolia*	*Curcuma gracillima*	*Curcuma thorelii*
0	43.5 a[z]	40.5 a	40.2 a	113 a	108 a	113 a
200	53.1 b	44.6 ab	43.7 ab	115 ab	114 a	115 a
400	57.1 b	44.6 ab	45.0 ab	128 b	109 a	113 a
600	55.4 b	47.9 b	51.2 b	126 ab	121 a	131 a

[z]Mean separation of GA rates by HSD test, P=0.05. Means within columns with different letters are significantly different.

Photoperiod

Tissue culture plants of *Curcuma petiolata* 'Emperor', *C. thorelii,* and *Kaempferia* sp. 'Grande' were planted one per 15 cm container in the greenhouse on 16 Aug. 1999. Tissue culture plants of *C. cordata* were planted two per 15 cm container on 9 Sept. 1999. Rhizomes of *C. alismatifolia* 'Siam Tulip White' were planted one per 12.5 cm container on 27 Aug. 1999. All ginger species were arranged in a complete randomized design under each photoperiod treatment.

Photoperiod treatments were initiated 17 d after transplanting for *C. alismatifolia C. petiolata*, *C. thorelii*, and *Kaempferia* sp. 'Grande' and 18 d after transplanting for *C. cordata*. On 2 Sept. 1999 photoperiod treatments of 8, 12, 16, and 20 hr were initiated. Plants received 8 hr of natural light from 0900 to 1700 hr. Zero, four, eight, and twelve hours of supplemental light were provided for the 8, 12, 16, and 20 hr photoperiod, respectively. Light source was 100 watt incandescent light bulbs at an irradiance of 11 µmol/s/m^2 (14 to 50 foot candles). Average minimum and maximum temperatures were 18° and 26.5°C. *Curcuma petiolata, C. thorelii*, 'Emperor', and *Kaempferia* sp. 'Grande' completed 21 weeks in the photoperiod treatment, *C. cordata* was 19 weeks and *C. alismatifolia* 18 weeks.

Each week, the number of newly unfolded leaves was counted as a measurement of plant growth. On 1 Dec. 1999, the height of the plants was measured from the medium surface to the tip of the longest leaf. On 1 Feb. 2000, the photoperiod treatment ended. Plants which did not go dormant during the course of the experiment were forced to dormancy by terminating irrigation. After all plants were dormant, the number of rhizomes and t-roots was counted for each treatment.

Dormancy was induced on all ginger grown under an 8 hr photoperiod. The number of weeks required for plants to go dormant under an 8 hr photoperiod was 9.0±0.17 weeks for *C. cordata*, 15±0 weeks for *C. petiolata*, 11.6±1.2 weeks for *C. thorelii*, and 12±0 weeks for *Kaempferia*.

Plant height of *C. alismatifolia* increased as length of photoperiod increased to 20 h (Table 2). *Curcuma cordata* plants grown at 20 and 16 hr were significantly taller than plants grown at 12 hr. Plants grown at 8 hr became dormant. *Curcuma petiolata* plants grown under 8 and 12 hr were significantly shorter than plants under 20 and 16 hr. *Curcuma thorelii* plants grown under 16 and 20 hr were significantly taller than plants at 12 hr. There were no significant differences in height between 12, 16, and 20 hr treatments for *Kaempferia*.

The number of leaves unfolded increased during the 16 and 20 hr photoperiod for *C. alismatifolia* (Table 3). *Curcuma cordata* plants under 16 and 20 hr photoperiods produced more new leaves than 8 and 12 hr photoperiods. *Curcuma petiolata* 'Emperor' plants grown at 16 and 20 hr produced more new leaves than plants grown at 8 and 12 hr (Table 3). Photoperiod did not significantly affect the number of new leaves *C. thorelii* produced. *Kaempferia* sp. 'Grande' plants in the 16 and 20 hr photoperiod produced more new leaves than those in 8 hr.

Curcuma alismatifolia, C. cordata, and *C. petiolata* plants grown under 16 and 20 hr produced a greater number of rhizomes than those plants grown under 8 and 12 hr (Table 4). Photoperiod did not affect the number of rhizomes produced by *C. thorelii* or *Kaempferia*. *Curcuma alismatifolia* grown under a photoperiod of 16 hr or less produced approximately two t-roots per plant and approximately one t-root at 20 hr (Table 5).

Table 2. Effect of photoperiod on plant height for *Curcuma alismatifolia* 'Chiang Mai White', *C. cordata*, *C. petiolata* 'Emperor', *C. thorelii*, and *Kaempferia* sp. 'Grande'.

	Plant height (cm)				
Photoperiod (hr)	*Curcuma alismatifolia*	*Curcuma cordata*	*Curcuma petiolata*	*Curcuma thorelii*	*Kaempferia* 'Grande'
8	20.7 a[z]	dormant[y]	35.6 a	dormant	dormant
12	30.0 b	42.7 a	41.6 a	32.0 a	31.6 a
16	38.8 c	50.2 b	65.3 b	37.3 b	46.6 a
20	35.6 bc	49.0 b	70.3 b	38.0 b	46.6 a

[z]Mean separation of photoperiods by HSD test, P=0.05. Means within columns with different letters are significantly different.
[y]Plants were dormant prior to measurement.

Table 3. Effect of photoperiod on total number of new leaves unfolded *Curcuma alismatifolia* 'Chiang Mai White', *C. cordata*, *C. petiolata* 'Emperor', *C. thorelii*, and *Kaempferia* sp. 'Grande'.

	Number of leaves unfolded				
Photoperiod (hr)	*Curcuma alismatifolia*	*Curcuma cordata*	*Curcuma petiolata*	*Curcuma thorelii*	*Kaempferia* 'Grande'
8	1.6 a[z]	0.5 a	2.6 a	2.0 a	2.0 a
12	2.1 a	2.8 a	3.3 a	4.6 a	3.3 ab
16	6.8 b	10.0 b	17.3 b	4.3 a	10.0 c
20	8.6 c	9.1 b	21.0 b	5.3 a	8.6 bc

[z]Mean separation of photoperiods by HSD test, P=0.05. Means within columns with different letters are significantly different.

Table 4. Effect of photoperiod on number of rhizomes of underground organs for *Curcuma alismatifolia* 'Chaing Mia White', *C. cordata*, *C. petiolata* 'Emperor', *C. thorelii*, and *Kaempferia* sp. 'Grande'.

	Number of rhizomes				
Photoperiod (hr)	*Curcuma alismatifolia*	*Curcuma cordata*	*Curcuma petiolata*	*Curcuma thorelii*	*Kaempferia* 'Grande'
8	1.0 a[z]	1.0 a	1.0 a	1.0 a	1.0 a
12	1.0 a	1.0 a	1.0 a	1.0 a	1.0 a
16	1.9 b	1.9 b	1.6 ab	1.0 a	1.0 a
20	2.3 c	2.1 b	3.0 b	1.0 a	1.3 a

[z]Mean separation of photoperiods by HSD test, P=0.05. Means within columns with different letters are significantly different.

Curcuma cordata, *C. petiolata*, and *Kaempferia* produced approximately 5 t-roots or more when grown at a photoperiod of 12 and 8 hr, and almost no t-roots at 16 and 20 hr. *Curcuma thorelii* responded to changes in photoperiod by producing a large number of t-roots for all treatments, producing the greatest number of t-roots at 16 hr.

Table 5. Effect of photoperiod on number of t-roots of underground organs for *Curcuma alismatifolia* 'Chaing Mia White', *C. cordata*, *C. petiolata* 'Emperor', *C. thorelii*, and *Kaempferia* sp. 'Grande'.

	Number of t-roots				
Photoperiod (hr)	*Curcuma alismatifolia*	*Curcuma cordata*	*Curcuma petiolata*	*Curcuma thorelii*	*Kaempferia* 'Grande'
8	2.1 b[z]	5.9 a	6.3 b	6.0 a	8.3 b
12	2.1 b	5.3 a	6.3 b	8.3 ab	4.6 b
16	1.9 b	0.0 b	0.3 a	11.6 b	0.0 a
20	0.6 a	0.0 b	0.6 a	10.6 ab	0.0 a

[z]Mean separation of photoperiods by HSD test, P=0.05. Means within columns with different letters are significantly different.

CONCLUSIONS

Curcuma spp. 'Precious Petuma', *C. parviflora* 'White Angel', and *C. alismatifolia* 'Chiang Mai Pink' produce marketable flowering pot plants requiring no application of shade. 'Precious Petuma' and 'White Angel' can be grown under shade levels of up to 60% without use of growth retardant and no deleterious affect on plant quality. 'Chiang Mai Pink' should be grown in full sun and an application of either 10 mg a.i./pot of uniconazole or over 20 mg a.i./pot of paclobutrazol for production of a quality flowering pot plant. These ornamental gingers have an excellent postproduction longevity of up to 40 days.

GA did not increase the number of inflorescences of *Curcuma alismatifolia* but did delay shoot emergence and flowering. GA applied (as a spray) at concentrations of 1.44 and 2.88 mM suppressed shoot emergence of field grown edible ginger (*Zingiber officinale* Roscoe) (Furutani and Nagao 1986). GA usually stimulates stem lengthening however, GA at 600 ppm significantly reduced flower height of *C. alismatifolia*. Soaking rhizomes in GA at 200, 300, 400, and 600 ppm did not inhibit shoot sprouting but delayed it. GA has been recommended for extending dormancy, thereby inhibiting sprouting in storage of yams (*Dioscorea cayenensis rotundata* Lam. and *D. alata* L.), an edible tuber (Girardin et al. 1998). Thus, GA could be used to prolong storage of ornamental ginger rhizomes prior to planting. It should not be used to promote or increase flowering.

Photoperiod affected height of all species of ginger evaluated. The plants grown under 20 or 16 hr photoperiods were taller than those grown under 12 or 8 hr photoperiods. Photoperiod affected the number of unfolded leaves of all plants except for *C. thorelii*. The 16 and 20 hr photoperiods increased number of leaves unfolded compared to 12 and 8 hr. Effect of photoperiod on number of rhizomes and number of t-roots was dependent upon the species of ginger. *Kaempferia* sp. 'Grande', *C. petiolata*, *C. cordata*, and *C. alismatifolia* 'Siam Tulip White' produced more t-roots when grown under 8 or 12 hr than 20 or 16 hr photoperiods. The exception was *C. thorelii*, where more t-roots where produced on the plants growing at 20 or 16 hr photoperiod than in 12 or 8 hr. *Siphonichilus decora* did not produce t-roots under any of the 4 photoperiods. *Curcuma petiolata, C. cordata*, and *C. alismatifolia* 'Siam Tulip White' produced more rhizomes under the long day photoperiods (20 and 16 hr) than under 12 or 8 hr.

Ginger shoot and rhizome growth were optimized when plants were grown under 16 or 20 hr photoperiods, whereas an 8 hr photoperiod promoted dormancy. The best production strategy for growers of gingers as flowering potted plants is to plant in the spring (April) and grow the plants throughout the summer, finishing production in the fall. If production in the winter is desired, 16 hr photoperiod must be used.

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