Planting Date and Night Break Treatment Affected Off-Season Flowering in *Curcuma alismatifolia* Gagnep.

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Abstract

Off-season flowering of *Curcuma alismatifolia* Gagnep. was studied in Chiang Mai Province of Thailand where the weather in winter is cool with temperatures between 16 to 30 °C, RH from 65 to 70 %, and 10 hrs of daylight. Rhizomes were stored at 15 °C for the 6 months from February to July, 2004. After root emergence, plants were grown under different night break treatments. Night break treatments were conducted by supplying 2 hrs of light daily from 20.00 to 22.00 hrs. The light source was 100 watt incandescent light bulbs. There were three treatments: T1, night breaks supplied from sprouting of the first shoot until the floral spike reached one inch long; T2 as T1, but continued until the first floret opened; T3, was a control treatment with no night break. Each treatment was carried out at different planting dates, i.e., August 9, September 9, October 9 and November 9. Plant height, number of plants per cluster, flowering percentage and flower qualities (number of coma bracts, number of green bracts, spike length and length of flower stalk) were recorded. The results showed that plant growth and flower qualities were similar with and without the night break treatment at the 9 August planting date. However, the September to October planting dates required night break treatments to promote flowering and maintain flower qualities.

Introduction

Curcuma alismatifolia Gagnep. or 'Siam tulip', in family Zingiberaceae is a native plant in Thailand. It is a high potential crop for cut flower and potted plant. Thailand exports about two million rhizomes per year to Japan, EU and USA.

Generally, flower and rhizome production starts from April to May, the plant flowers in July to August during the rainy season in Thailand, when the weather is averaging 27 to 28°C, 12 to13 hrs of sunshine duration, and 80% RH. Then, it becomes dormant in November to December, the rhizomes are harvested in December to February when the temperature is about 30/16°C (max/min), sunshine is about 10 hrs, and relative humidity (RH) is about 65 to 70%. High demand of flower in the world market is mostly in winter, when the environmental conditions, such as, short day length and low temperature in winter are limiting factors for growth and development of this plant.

All plants need light to use nutrients and manufacturing food. Artificial light is useful when natural light is insufficient. Plant absorbs red and blue lights, both are used in controlling photosynthesis, leaf development and flowering. Incandescent light can supplement natural day light and give a large amount of red light and infrared light (Barkley, 2005).

The responses of plants to day length were classified in three classes i.e. short-day plants (SD), long day plants, and day length neutral plants; however, this original classification has since become considerably more complex with various subclasses. Plants differ in respect of the strictness of dependence on day length were divided into, i.e., (1) qualitative or obligate photoperiodism, where there is an absolute requirement for a particular day length (SD or LD plants), and (2) quantitative or facultative photoperiodism, where a particular day length advances or enhances flowering, but the plants will eventually flower anyway (Hart, 1988). Interruption by light of dark period, called night break, can lead to floral promotion of LD plants (Thomas and Vince-Prue, 1997). Hagiladi *et al.* (1997) reported that *Cucurma alismatifolia* should be classified as quantitative long day plants, since long day condition using supplement light source enhances flowering of this plant. Therefore, the research was aimed to study the effect of planting date and night break treatment on growth and development of *C. alismatifolia* using incandescent light to extend flower production period from the rainy season to winter.

Materials and Methods

Stubbed rhizomes with storage roots of *Curcuma alismatifolia* were stored in cool room at 15 ^{o}C, RH from 70 to 80% for 6 months from February to July. The experiment using the storage rhizomes was started from August to November, plants were grown in different conditions at four different planting dates, 9 August; 9 September; 9 October; and 9 November. Before planting, the rhizomes were soaked in water for 3 days to stimulate sprouting, and planted in 6 x 12 inches plastic bags using sand : rice husk : rice husk charcoal (1:1:1) as planting medium. Water was supplied daily and nutrient solution containing 200 mg l $^{-1}$ of N, 50 mg l $^{-1}$ of P, 200 mg l $^{-1}$ of K, 65 mg l $^{-1}$ of Ca, 20 mg l $^{-1}$ of Mg, 0.22 mg l $^{-1}$ of B, 0.54 mg l $^{-1}$ of Mn, 0.26 mg l $^{-1}$ of Zn, 0.04 mg l $^{-1}$ of Mo and 0.45 mg l $^{-1}$ of Fe was supplied twice a week. For each planting date there were three treatments: T1, night break treatment started from shoot emerged until the flower spike reached one inch long; T2, night break treatment started from shoot emerged until the first floret opened; and T3, control treatment where plants were grown in natural conditions with no night break treatment. The growing plants were exposed to 2 hrs supplement light from 20.00-22.00 hrs. Light source was 100 watt of incandescent light bulbs emitting about 462 µmol s $^{-1}$ m $^{-2}$. Since growth rate of plants were different at different planting dates, therefore T1 and T2 had different light supplement duration depending on the planting dates as shown in Table 1. Plant growth in terms of plant height, number of plants per cluster, and flower quality were collected. The experimental design was a completely randomized design with 10 replications/treatment.

Table 1. Growing time required for starting night break treatments in T1 and T2 from different planting dates.

Planting dates	Time required after planting (wks)	
	T1 (from planting to one inch of flower spike appeared)	**T2** (from planting to opening of the first floret)
Aug. 9	9	11
Sep. 9	10	12
Oct. 9	12	14
Nov. 9	14	16

Results and Discussion

Plant growth

The results showed that growing habits of *C. alismatifolia* were not significantly different at planting dates of 9 Aug. and 9 Oct. On the other hand, they were affected by the night break treatments T1 and T2 compared with control (T3) when planted in 9 Sep., and 9 Nov. Heights of plants at late planting dates (9 Sep., 9 Oct. and 9 Nov.) were lower than early planting date in 9 Aug. (Table 2). Assuming that the average temperature in Thailand during that period was 20 to 24°C, which was cooler (26 to 27°C) than the other periods and sunshine duration was from 10 to 11 hrs (Table 3). Lower temperature during later planting dates has a deleterious effect on final plant growth and development. However, night break treatment could stimulate plant height compared with the control (Table 2).

Table 2. Plant height (cm) affected by night break treatments from different planting dates, 12 WAP.

Treatments	Planting dates			
	Aug. 9	Sep. 9 [1]	Oct. 9	Nov. 9 [1]
T1. night break until one inch of spike appeared	47.65	48.12a	42.70	34.40a
T2. night break until the first floret opened	50.08	55.62a	39.68	35.25a
T3. control (no night break)	45.08	32.48b	39.05	24.88b
LSD .05	ns	11.12	ns	6.38

[1] Means followed by different letters within the same column are significantly different among treatments; ns: not significantly different.

Table 3. Meteorological data during August–December in Chiang Mai Province at the Multiple Cropping Research Station, Chiang Mai University.

Month	Data			
	Air temp. (°C)			Sunshine duration (hrs)
	max	Min	avg	
August	32	23	27	12
September	32	23	27	12
October	32	21	26	11
November	31	19	24	11
December	29	13	20	10

Number of plants per cluster indicated the yield of rhizomes after harvest. The results showed that night break did not affect the number of plants per cluster of plants growing on 9 Aug., 9 Sep., and 9 Oct. (Table

4). However, the number of plants per cluster of the controlled treatment T3 was significantly lower than T1 when planted on 9 Nov. (Table 4). This indicates that the effect of night break was sensitive to low temperature during the growing period.

Table 4. Number of plants per cluster affected by night break treatments from different planting dates, 12 WAP.

Treatments	Planting dates			
	Aug. 9	Sep. 9	Oct. 9	Nov. 9 [1]
T1. night break until one inch of spike appeared	1.25	1.75	1.75	2.75a
T2. night break until the first floret opened	1.50	1.00	1.50	1.50ab
T3 control (no night break)	1.50	1.25	1.50	0.75b
LSD .05	ns	ns	ns	1.98

[1] Means followed by different letters within the same column are significantly different among treatments; ns: not significantly different.

Days to flowering

The number of days from planting to flowering tended to be delayed when plants were grown under night break treatments at the 9 Sep. and 9 Oct. planting dates. However, days to flowering in the 9 Nov. group was less (99.25 days) for T1 compared to the T3 control treatment (103 days) (Table 5). Night break treatments in T1 and T2 also increased flowering percentages, compared to the control (Table 6). The similar results were also found in *Cosmos atrosanguineus* (Hook.) Voss. (Kanellos and Pearson, 2000), *Petunia x hybrida* (Adams *et al*., 1999) and *Eustroma grandiflorum* (Raf.) Shinn. (Islam *et al*., 2005), the quantitative (facultative) long-day plants whose flowering was advanced and hastened by long day.

Table 5. Number of days to the first floret opening affected by night break treatments from different planting dates.

Treatments	Planting dates			
	Aug. 9	Sep. 9	Oct. 9	Nov. 9 [1]
T1. night break until one inch of spike appeared	68.75	85.75	98.00ab	99.25b
T2. night break until the first floret opened	79.75	89.50	102.50a	102.00ab
T3 control (no night break)	70.00	75.25	90.00b	103.00a
LSD .05	ns	ns	12.44	2.87

[1] Means followed by different letters within the same column are significantly different among treatments; ns: not significantly different.

Table 6. Flowering percentages affected by night break treatments from different planting dates.

Treatments	Planting dates			
	Aug. 9	Sep. 9	Oct. 9	Nov. 9
T1. night break until one inch of spike appeared	80.00	80.00	80.00	60.00
T2. night break until the first floret opened	86.70	100.00	66.70	86.70
T3. control (no night break)	66.70	53.30	46.70	26.70

Flower qualities

Flower qualities in terms of spike length, number of coma bracts, number of green bracts and length of flower stalk were determined. It showed that both of the night break treatments (T1 and T2) did not affect all flower quality parameters of the plants grown at 9 Aug. (Table 7 to 10). On the other hand, they increased length of spike in general (Table 7), number of coma bract (Table 8, Fig. 1) and length of flower stalk (Table 9) compared to the control treatment at 9 Sep., 9 Oct. and 9 Nov. planting dates. Length of spike in T1 were 14.05, 12.18 and 10.15 cm at 9 Sep., 9 Oct. and 9 Nov., respectively and they were not significantly different from T2, but they were significantly higher than control treatment (T3) (Table 7). Number of coma bracts were significantly higher in T1 (10.75, 12.00 and 10.50 bracts per spike at 9 Sep., 9 Oct. and 9 Nov., respectively) and T2 (13.00 and 10.75 bracts at 9 Sep. and 9 Nov., respectively) than control treatment (T3) (Table 8). The results of flower stalk length were similar to length of spike (Table 9). Chang (2000) also reported that to extend flowering period of *C. alismatifolia* in Taiwan using plastic tunnel and light illumination from 22.00 p.m. to 2.00 a.m. increased quality on length of flower stalk, diameter of stalk and number of coma bract. However, number of green bracts was not significantly different among treatments at each planting date (Table 10). Later planting dates had adverse effect, giving less flower qualities although the plants were supplied with night break and also affected flower morphology as showed in Fig. 1.

For short day plant, such as chrysanthemum, night break is used for floral bud initiation. In case of *C. alismatifolia*, a quantitative long-day plant, night break seems to involve in extending photosynthetic period and stored assimilates required for growth and flowering.

Table 7. Length of spike (cm) affected by night break treatments from different planting dates.

Treatments	Planting dates			
	Aug. 9	Sep. 9 [1]	Oct. 9 [1]	Nov. 9 [1]
T1. night break until one inch of spike appeared	17.13	14.05ab	12.18ab	10.15a
T2. night break until the first floret opened	16.63	16.48a	12.45a	9.32a
T3. control (no night break)	17.38	13.45b	11.10b	7.22b
LSD .05	ns	2.77	1.26	0.97

[1] Means followed by different letters within the same column are significantly different among treatments; ns: not significantly different.

Table 8. Number of coma bracts affected by night break treatments from different planting dates.

Treatments	Planting dates			
	Aug. 9	Sep. 9 [1]	Oct. 9 [1]	Nov. 9 [1]
T1. night break until one inch of spike appeared	12.50	10.75ab	12.00a	10.50a
T2. night break until the first floret opened	12.00	13.00a	9.25b	10.75a
T3. control (no night break)	13.25	8.75c	9.50b	8.25b
LSD .05	ns	1.98	1.93	4.57

[1] Means followed by different letters within the same column are significantly different among treatments; ns: not significantly different.

Table 9. Length of flower stalk (cm) affected by night break treatments from different planting dates.

Treatments	Planting dates			
	Aug. 9	Sep. 9 [1]	Oct. 9 [1]	Nov. 9 [1]
T1. night break until one inch of spike appeared	40.25	54.38ab	31.25a	31.30a
T2. night break until the first floret opened	42.13	62.38a	28.20a	28.38a
T3. control (no night break)	40.50	43.38b	22.75b	16.62b
LSD .05	ns	12.60	5.29	6.13

[1] Means followed by different letters within the same column are significantly different among treatments; ns: not significantly different.

Table 10. Number of green bract affected by night break treatments at different planting dates.

Treatments	Planting dates			
	Aug, 9	Sep. 9 [1]	Oct. 9 [1]	Nov. 9 [1]
T1. night break until one inch of spike appeared	8.75	9.00	8.75	7.00
T2. night break until the first floret opened	8.75	9.75	8.25	9.25
T3. control (not supplied night break)	10.00	9.50	8.50	7.00
LSD .05	ns	ns	ns	ns

[1] Means followed by different letters within the same column are significantly different among treatments; ns: not significantly different.

a) planted on 9 Aug., flowered in late Oct.

b) planted on 9 Sep., flowered in beginning of Dec.

c) planted on 9 Oct., flowered in beginning of Jan.

d) planted on 9 Nov., flowered in beginning of Feb.

Figure 1. Flower qualities influenced by night break and planting dates.

Conclusion

It was possible to produce off-season flower of *Curcuma alismatifolia* by storing rhizome in a controlled room at 15°C, then stimulate shoot emergence by soaking the rhizome in water for three days. It was not necessary to supply night break when planted on August 9. However, for delayed growing in September to November, night break treatment was necessary to promote flowering, flowering percentage and increased flower qualities in December and January. Duration of night break treatments between T1 and T2 were not significantly different, therefore night break should be supplied from shoot emerged until one inch of tight flower spike appeared (T1) which was sufficient for off-season flowering.

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