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Influence of Temperatures during Long-night Exposures on Growth and Flowering of 'Mace', 'Thor', and 'Telstar' Kalanchoe[1]

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Abstract. ***Kalanchoe*** **× sp. cvs. Mace, Thor, and Telstar were subjected to 2, 3, 4, or 5 weeks of long nights (LN) at 10, 16, or 21°C. The cultivars varied in the number of LN for 100% flowering, and this was influenced by temperature. No temperature was more inductive than 16°C; yet, 'Thor' required twice as many LN as 'Mace'. After 2 weeks of LN the relative growth-rate patterns among 'Mace' plants under non-inductive conditions continued, but the patterns of 'Thor' and 'Telstar' changed. Flowering after 2 weeks of LN averaged 91.7% for 'Mace', nil for 'Thor', and 25.3% for 'Telstar'.**

Kalanchoes are attractive, long-lasting pot plants which flower in mid-Jan. if grown at 16°C under naturally-occurring nightlengths (2). Because they are LN plants, they are flowered year-round, like chrysanthemums; however, "heat delay" can occur from high temp in summer (11). Low temp reportedly delay flowering (2, 7).

Although some are commercially produced at 10°C, cultural recommendations for flowering plants vary considerably with respect to night temp (16 to 21°C) and no. of LN (3 to 6 wk) required (2, 4, 6, 7).

Spear (10) found that kalanchoes adjust to LN exposure: under SN, net CO_2 uptake is in light and net production in dark; but, under LN, net CO_2 uptake occurs in dark and net production in light. However, once induced to complete flowering, the plant does not revert to a SN pattern if given SN – it continues net CO_2 uptake in dark and production in light. Because changes in CO_2 utilization/production occur with photoperiod variation, one might expect differences in plant growth, but this was not reported.

This research was conducted under precisely-controlled conditions to define the effects of 4 periods of LN at 3 temp on inflorescence initiation and development among 3 cultivars. Shoot growth under SN and LN exposures was measured to determine if differences existed.

Five-month-old assexually propagated 'Mace', 'Thor', and 'Telstar' kalanchoe plants were grown under non-inductive conditions and transported from Clemson, S.C., to the Southeastern Plant Environment Laboratories (SPEL) (5) at Raleigh, N.C., where the treatments were applied. Shoots had been pinched 8 weeks earlier. On arrival, plants were repotted in 15.2-cm standard plastic pots, using a mixture of No. 16 mesh gravel and Jiffy Mix (2:1 by vol). They were watered daily and received the N.C.S.U. Phytotron Nutrient Solution daily.

Light radiation at plant level within growth chambers averaged 455 hectolux, yielding a photon flux density of ca. 700 uE^{-2} sec^{-1} of photosynthetically active radiation and ca. 12 w m^{-2} between 700 and 800 nm, as given by incandescent and cool white fluorescent lamps.

Control conditions consisted of 8 hr light/24-hr cycle at 21°C and a 6-hr, mid-dark interruption of the same light at 16°C. Two, 3, 4, or 5-week inductive treatments of 8 hr light/24-hr cycle at 21°C with 10, 16, or 21°C dark periods were applied. When not under treatment conditions, plants were under control conditions. Four plants per treatment of 'Mace' and 6 each of 'Thor' and 'Telstar' were tested in a completely random experiment. Previous observations have shown 'Mace' more responsive to LN. Initially, 2 shoots per plant were randomly selected and tagged to determine no. of nodes formed from a reference point.

At the end of the 5 weeks of treatments, plants were returned to Clemson and grown under non-inductive conditions until final data were taken.

Neither control plants which remained at Clemson nor those transported to SPEL flowered. Both were growing vegetatively 5 months after the treatments were begun.

While growing 5 weeks under LN, 'Mace' grew more at higher than lower night temp, differing about a node between 10 and 21°C (Fig. 1). Plants returned to control conditions after 2 weeks LN grew as when under LN: those previously at higher temp grew more than those at lower temp even though they were all under the same control conditions. Controls grew similarly to plants at 10°C during LN.

Control shoots of 'Thor' grew slightly more than those receiving LN (Fig. 1). Shoots receiving LN differed less than a node of growth. When

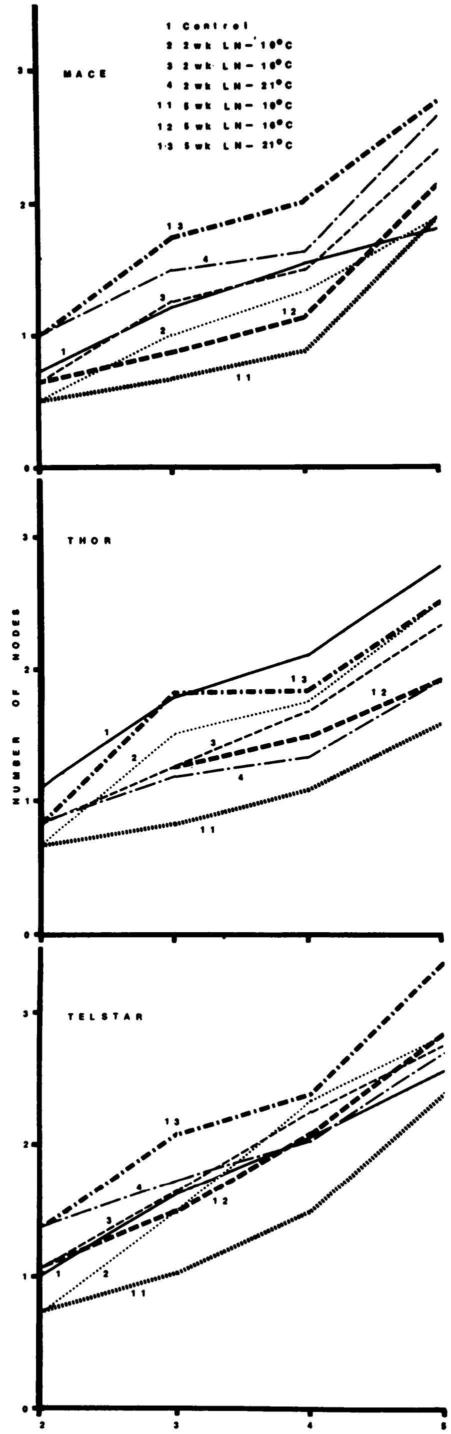

Fig. 1. Comparative total node production/shoot above that present at commencement of treatments of 'Mace', 'Thor', and 'Telstar' kalanchoe.

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Table 1. Effects of 0, 2, 3, 4, or 5 weeks of long nights at 10, 16, or 21°C on percent flowering, cyme branching, and days-to-flower of 'Mace', 'Thor', and 'Telstar' kalanchoe.

Treatment		Mace				Thor				Telstar			
			No. cyme branches				No. cyme branches				No. cyme branches		
		% flowering[z]	Primary	Secondary	No. days to flower[y]	% flowering	Primary	Secondary	No. days to flower	% flowering	Primary	Secondary	No. days to flower
1. Control		0	0.0b[x]			0	0.0e			0	0.0e		
2. 10°C		75	4.3a	0.7a	60.3a	0	0.0e			17	0.4de	1.0a	62.0a
3. 16°C	2 wk	100	4.5a	0.7a	47.8a	0	0.0e			42	1.0cde	1.2a	55.0a
4. 21°C		100	4.4a	1.3a	46.8b	0	0.0e			17	0.3de	1.0a	49.0ab
5. 10°C		75	4.5a	1.0a	48.0b	17	1.1de	0.0a		58	1.4bcd	1.3a	46.0ab
6. 16°C	3 wk	100	5.8a	1.1a	44.0b	25	1.7cde	0.0a	69.0a	100	2.9a	1.3a	39.8b
7. 21°C		100	5.8a	1.0a	44.8b	8	0.4e	0.0a	53.0b	42	1.2cde	1.4a	48.7ab
8. 10°C		100	5.4a	0.8a	45.0b	100	3.8ab	1.0a	53.0b	92	2.1abc	1.5a	45.0b
9. 16°C	4 wk	100	4.8a	1.0a	33.3de	100	3.4ab	1.5a	49.8bc	100	2.5ab	1.4a	42.0b
10. 21°C		100	5.5a	1.3a	33.8d	100	2.3bcd	1.6a	48.2bc	92	2.5ab	0.9a	46.5ab
11. 10°C		100	5.1a	1.1a	38.8c	100	4.8a	0.9a	47.5bc	100	2.7a	1.1a	43.3b
12. 16°C	5 wk	100	4.8a	1.1a	30.5de	100	2.8bc	1.3a	38.5d	100	2.7a	1.6a	38.2b
13. 21°C		100	5.3a	1.0a	29.3e	100	3.1bc	1.7a	43.8cd	92	2.2abc	1.2a	38.5

[z]Based on no. of shoots initially tagged that flowered.

[x]Mean separation within columns by Duncan's multiple range test, 5% level.

[y]Number of days from end of LN sequence to opening to central flower of inflorescence.

returned to control conditions after 2 weeks LN, the relative shoot growth rates changed: those previously exposed to high temp grew less than those exposed to lower temp (Fig. 1).

At the end of 5 weeks, the differences among 'Telstar' shoots which had received 2 weeks of LN were small; however, as with 'Thor', when returned to control conditions following 2 weeks LN, the relative growth rates changed similarly to 'Thor' (Fig. 1).

'Mace' shoots flowered 100% with 2 weeks LN at 16 or 21°C (Table 1); however, 4 weeks LN were required for 100% flowering at 10°C, indicating more LN are required for complete flower induction at low temp. Also, 10°C LN delayed days-to-flower at the 4- and 5-week levels, where 100% flowering occurred (Table 1). No differences in cyme primary or secondary branching were found among flowering shoots (Table 1); therefore, once induced, 'Mace' flower initiation followed rapidly and/or continued under noninductive conditions. The inflorescence, a compound dichasium (cyme), can branch along the central axis (primary branching) and on lateral shoots (secondary branching) (9).

Four weeks of LN were required for 100% flowering of 'Thor', but some shoots flowered with 3 weeks LN (Table 1). At the 5-week-LN exposure level, more primary inflorescence branching developed on shoots given 10°C, but they flowered later than those grown at 16°C (Table 1). No differences in secondary branching occurred within any LN-exposure level.

Apparently, both 10°C and 21°C LN restrain flower induction of 'Telstar': higher percentages of flowering occurred at 16°C at the 2- and 3-week levels (Table 1).

When 2 weeks LN resulted in high flowering percentages for a cultivar, shoots grew at a common temp under SN as when under LN at different temp; but, when 2 weeks LN was insufficient, shoot growth changed under SN. The percentages of 'Mace' that flowered were high when 2 weeks of LN were given (Table 1); and, after being returned to control conditions, plants continued to grow in a pattern similar to those which received 5 weeks LN regardless of the common temp (Fig. 1). 'Thor' did not flower with 2 weeks LN, and the percentages of 'Telstar' that flowered were less than 50%. After 2 weeks LN, both cultivars changed with relative growth patterns. Those previously at 16°C grew more and those at 21°C less, their positions reversing. Considering the findings of Spear (10), one would expect changes in growth to result because of alterations in the CO_2 utilization/production rhythm that occurs under SN when a plant is not highly induced to flowering.

Implementation of minimum cultivar requirements for maximum flowering can reduce production time considerably. A 16°C exposure during LN was most inductive. Low temp (10°C) reduced flowering with fewer LN. High temp reduced flowering of 'Thor' with less than 4 weeks LN and 'Telstar' at all LN levels. No blanket statement on weeks of LN required for complete flowering can be made. 'Thor' required twice as many LN as 'Mace' for 100% flowering at 16°C, illustrating wide enough variation to necessitate the realization of specific cultivar-production schedules. Primary branching was influenced by temp, but it generally increased with the percentage of flowering. Temp during LN-exposure influenced plant growth and flowering. Plants at higher temp during LN grew more. Neither temp nor SN altered growth when plants were highly induced to flowering.

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