PAN. Even at this higher dose of PAN, the tolerant 'Coral Magic', exhibited little injury. Foilage not treated with benomyl averaged 14% injury while treated tissue exhibited mean injury levels from 10% to 21%.

Our previous report of the lack of protection of benomyl for PAN injury in pinto bean or 'White Cascade' petunia (10, 11) has been confirmed for 'White Cascade' and 'Coral Magic' petunias in this study. Benomyl significantly enhanced the PAN response in 'White Cascade' petunias at 60-120 μg/g soil.

The threshold for benomyl induced enhancement of the PAN response appears to be 60 μg/g soil. Additional benomyl apparently does not increase susceptibility of the site(s) of action of PAN to any greater extent. The physiological explanation for benomyl enhanced PAN response is subject to speculation. Benomyl has been characterized as an antisenescing agent (18), and PAN injures young immature tissue (17). It is possible that benomyl is maintaining the plant at a stage of optimal sensitivity.

The inability of benomyl to enhance the PAN response in 'Coral Magic' petunia may be related to its inherent tolerance to PAN. It is also possible that when injury severity levels are low, as occurred when 'Coral Magic' was challenged with PAN, differences are more difficult to detect. Experiments in which higher levels of PAN were used, would be necessary to elucidate the response of 'Coral Magic'.

Benomyl can prevent injury from ozone (4, 5, 6, 7, 8, 9, 13) but not from all oxidants. In many polluted atmospheres ozone is the major phytotoxic oxidant and hence benomyl would be an appropriate protectant. However, when chemicals are evaluated in the effort to reduce air pollution injury to plants consideration should be given to other atmospheric contaminants.

Literature Cited

1. DeVos, Neal. 1977. The inheritance of peroxyacetyl nitrate (PAN) resistance in petunia, *Petunia hybrida Vilm.* MS Thesis, Penn. State Univ., University Park.
2. Drummond, D. B. 1972. The effect of peroxyacetyl nitrate on petunia (*Petunia hybrida Vilm*). Center for Air Envoronment Studies 260-272. Penn. State Univ., University Park.
3. Feder, W. A., F. L. Fox. W. W. Heck, and F. J. Campbell. 1969. Varietal responses of petunia to several air pollutants. *Plant Dis. Rptr.* 53:506-510.
4. Kender, W. J. 1973. Benomyl protection of grapevines from air pollution injury. *HortScience* 8:396-398.
5. Manning W. J., W. A. Feder, and P. M. Vardaro. 1973. Benomyl in soil and response of pinto bean plants to repeated exposures to a low level of ozone. *Phytopathology* 63:1539-1540.
6. Manning, W. J., W. A. Feder, and P. M. Vardaro. 1974. Suppression of oxidant injury by benomyl: Effects on yields of bean cultivars in the field. *J. Environ. Qual.* 3:1-3.
7. Moyer, J. W. 1973. The influence of systemic compounds on the occurrence of ozone injury to ornamental plants. MS Thesis, Penn. State Univ., University Park.
8. Moyer, J. W., H. Cole, Jr., and N. L. Lacasse. 1974. Reduction of ozone injury on *Poa annua* by benomyl and thiophanate. *Plant Dis. Rptr.* 58:41-44.
9. Moyer, J. W., H. Cole, Jr., and N. L. Lacasse. 1974. Suppression of naturally occurring oxidant injury on azalea plants by drench or foliar spray treatment with benzimidazole or oxathiin compounds. *Plants Dis. Rptr.* 58:136-138.
10. Pell, E. J. 1976. Influence of benomyl soil treatment on pinto bean plants exposed to peroxyacetyl nitrate and ozone. *Phytopathology* 66:731-733.
11. Pell, E. J. and W. Gardner. 1975. Benomyl stimulation of peroxyacetyl nitrate injury to petunia. *Proc. Amer. Phytopathol. Soc.* 2:29 (Abstr.)
12. Pellisier, M., N. L. Lacasse, and H. Cole, Jr. 1971. Uptake of benomyl by bean plants. *Phytopathology* 61:132 (Abstr.)
13. Pellister, M., M., N. L. Lacasse, and H. Cole, Jr. 1972. Effectiveness of benomyl-folicote treatments in reducing ozone injury to pinto beans. *J. Air. Pollut. Control Assoc.* 22:722-725.
14. Smith, R. G., R. J. Bryan, M. Feldstein, B. Levadie, F.A. Miller, and E.R. Stephens. 1972. Tentative method of analysis. for peroxyacetyl nitrate (PAN) in the atmosphere (Gas chromatographic method). p. 215-219. *In* Methods of air sampling and analysis. Amer. Pub. Health Assoc., Washington, DC.
15. Steiner, A. A. 1961. A universal method for preparing nutrient solutions of a certain desired composition. *Plant & Soil* 15:134-135.
16. Taylor, O. C., W. M. Dugger, E. A. Cardiff, and E. F. Darley. 1961. Interaction of light and atmospheric photochemical products (smog) within plants. *Nature* 192:814-816.
17. Taylor, O. C., E. R. Stephens, E. F. Darley, and E. A. Cardiff. 1960. Effect of air-borne oxidants on leaves of pinto bean and petunia. *Proc. Amer. Soc. Hort. Sci.* 75:435-444.
18. Tomlinson, H. and S. Rich, 1973. Antisenescent compounds reduce injury and steroid changes in ozonated leaves and their chloroplasts. *Phytopathology* 63: 903-906.
19. Waller, R. A. and D. B. Duncan. 1969. A Bayes rule for the symmetric multiple comparison problems. *J. Amer. Statis. Assoc.* 64:1484-1503.
20. Wood, F. A., D. B. Drummond, R. G. Wilhour, and D. D. Davis. 1973. An exposure chamber for studying the effects of air pollutants on plants. Penn. State Univ. Agric. Expt. Stn. Prog. Rpt. 335. University Park.

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Effect of Inductive Photoperiodic Cycles on Flowering of Kalanchoe Cultivars[1]

William H. Carlson, Carole A. Turner, and Jack Schnabel[2]

Department of Horticulture, Michigan State University, East Lansing, MI 48824

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Abstract. **'Gelbe Melody', 'Mace', 'Red Mace', 'Rotkappchen', 'Sirius', and 'Solferinopurpur' (*Kalanchoe* x spp.) required a minimum of 14 inductive photoperiodic cycles for normal flowering; 'Feuerwerk II', 'Jupiter', and 'Roterpfeffer' required 21; 'Feuerball', 'Feuerzauber', 'Granta', and 'Korall' required 28; and 'Cherie' required 35.**

Kalanchoe cultivars are grown commercially year-round through photoperiodic manipulation similar to chrysanthemums, with an extended period of long nights (LN) for flower initiation and development (1, 2). However, these cultivars are a diverse group and vary in their response to number of LN. Pertuit (4) noted enough variation to recommend cultivar-specific schedules, especially in relation to temperature.

Commercial growers have experienced difficulties with transitional flowering, characterized by fewer florets and incomplete development of the florets and inflorescences. In normal flowering, bracts are very small and scale-like, with the inflorescence a dichasial cyme ending in cincinni (3). With incomplete initiation, the inflorescence exhibits less bifurcation and florets, with larger, more developed bracts (phyllody). Under minimum inductive conditions, there may be only 1 bifurcation and 1 floret, with some lateral shoot development (5). This reaction is regulated by the amount of stimulus (i.e., LN cycles) applied (3).

This study was conducted to determine the minimum number of LN needed to induce full flowering of 14 kalanchoe cultivars under greenhouse conditions.

Rooted cuttings were planted February 13, 1976 in 10-cm clay pots, using a 1 pasturized soil:1 peat :1 perlite (by volume) mixture. The plants were grown in a randomized block experiment in a 16.8°C (night), 21 to

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[2]Professor and graduate students, respectively.

Table 1. Effect of number of inductive cycles on days to first open floret of 14 kalanchoe cultivars.

Cultivar	Days to first open floret										
	No. of inductive cycles (15 hr dark/9 hr light)									Continuous long nights	HSD (1% level)
	0	7	14	21	28	35	42	49	56		
Gelbe Melody	--^{z}	--^{z}	75.2	83.2	75.0	73.7	73.5	76.2	75.0	75.7	11.1
Mace	--^{z}	--^{z}	67.5	68.5	68.0	68.7	69.0	73.5	71.3	72.5	3.3
Red Mace	--^{z}	103.7^{x}	65.7	65.2	65.8	67.7	67.7	70.3	70.0	71.5	7.7
Rotkappchen	--^{z}	--^{z}	70.7	69.7	70.0	70.2	72.2	73.7	72.5	73.0	4.3
Sirius	--^{z}	--^{z}	73.3	74.2	74.8	74.2	76.5	79.7	78.0	78.5	5.1
Solferinopurpur	--^{z}	84.7^{x}	77.0	75.5	74.2	76.8	76.0	76.7	78.5	77.7	5.6
Feuerwerk II	--^{z}	--^{z}	86.0^{xz}	74.2	74.7	73.2	74.0	74.8	74.5	72.0	11.8
Jupiter	--^{z}	--^{z}	82.7^{y}	69.0	70.8	71.5	73.0	72.2	73.5	71.5	9.6
Roterpfeffer	--^{z}	--^{z}	92.7^{xy}	77.0	77.3	78.0	78.5	78.0	78.8	75.2	10.6
Feuerball	--^{z}	--^{z}	--^{z}	78.7^{y}	77.0	75.3	76.3	78.7	79.3	76.2	5.9
Feuerzauber	--^{z}	--^{z}	102.0^{xy}	77.8^{y}	75.3	76.2	76.3	76.0	76.5	74.0	8.9
Granat	--^{z}	--^{z}	108.3^{xy}	85.8^{y}	76.5	80.7	79.2	80.8	82.3	78.2	13.6
Korall	--^{z}	--^{z}	--^{z}	80.0^{y}	78.8	77.2	77.5	79.0	79.8	79.7	5.6
Cherie	--^{z}	--^{z}	--^{z}	103.0^{xy}	83.8^{y}	82.0	82.3	83.5	84.5	83.5	9.2

^{z}Plants did not flower by termination of experiment.

^{y}Transitional florets present.

^{x}Non-flowering plants assigned a value of 112 days in this average.

Table 2. Effect of no. of inductive cycles on number of cymes plant of 14 kalanchoe cultivars.

Cultivar	No. cymes										
	No. of inductive cycles (15 hr dark/9 hr light)									Continuous long nights	HSD (1% level)
	0	7	14	21	28	35	42	49	56		
Gelbe Melody	0.0**	0.0**	14.0	18.8	14.0	15.2	17.3	13.8	15.0	15.0	3.8
Mace	0.0**	0.0**	15.5	16.2	18.3	17.0	17.7	15.7	16.5	15.0	3.6
Red Mace	0.0**	4.0**	18.3	16.0	16.7	16.7	19.7	15.7	16.7	16.5	5.5
Rotkappchen	0.0**	0.0**	18.0	14.5	15.7	19.2	19.2	17.2	19.7	14.7	4.0
Sirius	0.0**	0.0**	18.2	17.5	17.7	19.0	21.7	17.8	18.5	18.0	5.0
Solferinopurpur	0.0**	3.5**	12.8	13.5	13.3	17.5	15.3	15.7	17.8	13.7	3.6
Feuerwerk II	0.0**	0.0**	3.0**^{z}	16.3	16.7	18.5	16.8	18.3	17.0	17.3	6.2
Jupiter	0.0**	0.0**	2.8**^{z}	17.5	18.5	19.0	17.8	18.3	19.8	18.3	5.7
Roterpfeffer	0.0**	0.0**	1.2^{z}	12.2	17.3	16.2	17.0	16.3	18.2	16.2	6.3
Feuerball	0.0**	0.0**	0.0**	18.5**^{z}	23.3	24.3	21.7	23.2	25.5	25.7	5.8
Feuerzauber	0.0**	0.0**	0.2**^{z}	12.2^{z}	16.5	19.7	20.3	19.3	19.3	19.8	9.2
Granat	0.0**	0.0**	0.2**^{z}	3.2**^{z}	14.3	17.7	13.7	13.3	13.8	12.5	4.5
Koral	0.0**	0.0**	0.0**	3.8**	15.7	16.2	19.8	16.0	18.0	17.7	6.0
Cherie	0.0**	0.0**	0.0**	3.0**	9.2**	20.2	20.2	19.8	20.2	20.7	5.6

^{z}Transitional florets present.

**Significantly different from saturated response (continuous long nights) at 1% level.

24^{o} (day) greenhouse, under natural photoperiods. Four-hr night breaks of 100 W/m^{2} incandescent light applied in the middle of 15-hr nights produced by black cloth applications were started 2 weeks after planting on these non-pinched plants to produce non-inductive, short nights (SN).

Nine treatments of 0 to 8 weeks of LN, in addition to a continuous LN to flowering were applied, using 6 plants/ per cultivar/ per treatment. Plants were placed under non-inductive (SN) conditions following the inductive treatment.

Plants were tagged daily. Those budded but not flowered by June 5 were assigned a value of 112 days when averaged with flowering plants in transactional treatments in Table 1. Vegetative plants were not included in the analysis of time to first open floret.

Only peduncles originating from the main axis were included in the cyme determinations. Any deviation from the saturated response of a cultivar (i.e., that value determined for the continuous LN treatment) was considered transitional flowering. Normal development of all plants in a treatment was considered full flowering.

'Gelbe Melody', 'Mace', 'Red Mace', 'Rotkappchen', 'Sirius' and 'Solferinopurpur' were induced fully after 14 LN (Table 1). All plants per cultivar in this treatment developed normal florets based on the number of cymes being not significantly different from the saturated response treatment (Table 2). Twenty-one LN were necessary for full flowering for 'Feuerwerk II', 'Jupiter', and 'Roterpfeffer', while 'Feuerball', Feuerzauber', 'Granta', and 'Korall' required 28 LN. 'Cherie' had the longest requirement (35 LN).

The number of cymes initiated along the main floral axis also differed among cultivars. Even when 'Red Mace', 'Solferinopurpur', 'Korall', and 'Cherie' initiated fewer cymes (i.e., not fully induced), all cymes developed fully and contained no transitional florets (Table 2). 'Mace' also followed this pattern in another unpublished study. The remaining cultivars exhibited transitional flowering characterized by bract phyllody, fewer cymes and florets, and no central cyme.

Under controlled temperature, kalanchoe plants respond more quickly and uniformly to fewer LN. However, temperature variations can change the number of LN required for 100% flowering (4). A cultivar-specific production schedule would help eliminate some of the problems encountered by commercial growers. During winter months, more economical production would be possible by selecting cultivars that reach anthesis with fewer LN.

Literature Cited

1. Ball, V. 1975. Kalanchoe p. 372 *In* V. Ball (ed.) The Ball red book. George J. Ball, Chicago, Illinois.
2. Carlson, W.H. 1975. The culture of *Kalanchoe blossfeldiana* 'Mace'. *Mich. Florist* 531:31,34.
3. Harder, R. 1948. Vegetative and reproductive development of *Kalanchoe blossfeldiana* as influenced by photoperiod. *Symp. Soc. Expt. Biol.* 2:117-137.
4. Pertuit, A. J. 1977. Influence of temperature during long-night exposures on growth and flowering of 'Mace', 'Thor', and 'Telstar' Kalanchoe. *HortScience.* 12:48-49.
5. Schwabe, W. W. 1969. *Kalanchoe blossfeldiana* Poellniz. p. 227-246 *In* L.T. Evans (ed.) The induction of flowering. Some case histories. Cornell Univ. Press, Ithaca, N.Y.