Literature Cited

1. Baker, R., and S. D. Dottarar. 1977. Mechanism of biological control of Fusarium stem rot of carnation. *Proc. Am. Phytopath. Soc.* 4:202.
2. Buxton, E. W. 1955. Fusarium diseases of gladiolus. *Trans. Brit. Mycol. Soc.* 38:193-201.
3. Forsberg, J. L. 1955. Fusarium disease of gladiolus: its causal agent. *Ill. Nat. Hist. Survey Bul.* 26:447-503.
4. Magie, R. O. 1951. Limitations of resistance to gladiolus fusarium disease. *Gladiolus Mag.* 15(4):2, 36-38.
5. ———. 1953. Some fungi that attack gladioli. Plant Diseases. *In* USDA Yearbook of Agriculture, 1953. p 601-607.
6. ———. 1971. Carbon dioxide treatment of gladiolus corms reveals latent Fusarium infections. *Plant Dis. Reptr.* 55:340-341.
7. ———. 1972. Disease and pest associates of bulb and plant. The World of the Gladiolus. North Amer. Gladiolus Council. p 155-181.
8. Massey, L. M. 1926. Fusarium rot of gladiolus corms. *Phytopathology* 16:509-523.
9. McClellan, W. D., and N. W. Stuart. 1947. The influence of nutrition on fusarium basal rot of narcissus and on fusarium yellows of gladiolus. *Amer. J. Bot.* 34:88-93.
10. ———. 1947. The symptoms of the Fusarium disease of gladiolus. *Gladiolus Mag.* 11(1):26-32. (Also in *NAGC Bul. 9:40-42*).
11. McCulloch, L. 1944. A vascular disease of gladiolus caused by Fusarium. *Phytopathology* 34:263-287.
12. Palmer, J. G., R. L. Pryor, and R. N. Steward. 1965. Resistance of gladiolus to Fusarium yellows. *Proc. Amer. Soc. Hort. Sci.* 86: 656-661.
13. Woltz, S. S. 1972. Soils and fertilizers. The World of the Gladiolus. *North Amer. Gladiolus Council.* p 149.
14. ———, and R. O. Magie. 1975. Gladiolus Fusarium disease reduction by soil fertility adjustments. *Proc. Fla. State Hort. Soc.* 88:559-562.
15. ———, ———, Constance Switkin, P. E. Nelson, and T. A. Toussoun. 1978. Gladiolus disease response to prestorage corm inoculation with Fusarium species. *Plant Dis. Reptr.* 62:134-137.

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FOLIAR CHLOROSIS OF KALANCHOE BLOSSFELDIANA POELLN. AS INFLUENCED BY TEMPERATURE, DARKNESS, AND ETHYLENE[1,2]

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Abstract. Kalanchoe blossfeldiana **Poelln. plants were held in simulated shipping environments with variables of air ± 0.5 ppm ethylene, temperature, and light exposure regimes for 2 and 3 days. Plants held in light (1.3 klx for 12 hr/day) for 2 days at 23.5°C did not become chlorotic, whereas those held in darkness became severely chlorotic. Ethylene increased the number of chlorotic leaves on plants held in the dark but had no effect when plants were held in the light. With each successive increase in temperature from 23 to 28 to 33°C, plants held in darkness with or without ethylene had increased leaf chlorosis. Plants held in darkness for 3 days contained less chlorophyll than those held for 2 days. These simulated shipping tests suggested that, in transit, leaf chlorosis of kalanchoe occurs when plants are packaged (held in darkness) and subjected to elevated temperatures for 2 or more days.**

Kalanchoe plants have increased in popularity in the last few years, and the increased demand for this flowering plant has resulted in an increase in the numbers of propagating specialists who produce the plants asexually (from cuttings) and ship them to growers, who force the plants to flowering size. Plants generally have been observed to arrive at their destination in poor condition, principally because of leaf chlorosis. Although some reports are available on the effects of environment during the growing period (8, 9, 10), little research has been reported on the shipping and handling environment of kalanchoe. Marousky and Harbaugh (5) reported that minute quantities of ethylene induced floret sleepiness, foliar chlorosis, and abscission in mature flowering plants. Sheehan and Nell (11) reported that light and fertilizer used during the plant growing phase influenced the degree of chlorosis during the postharvest phase.

In this paper, we report the effects of temperature, darkness, and ethylene on development of leaf chlorosis and loss of chlorophyll in *Kalanchoe blossfeldiana* Poelln. plants during simulated shipping conditions.

Materials and Methods

Kalanchoe plants in 6 cm (2.3 inch) square plastic pots were obtained commercially. Plants were 2-3 weeks old (after transplanting) and had been growing under a short night environment (i.e. vegetative). All experiments were started and terminated during the afternoon and repeated at least once. All treatments had a minimum of 6 plants. The general procedures for mixing ethylene and air and distributing gases in chambers were similar to those previously reported (6). Air and ethylene flow was regulated to provide one complete change of air per chamber every 30-35 min. After exposure, the number of chlorotic leaves on each plant was counted. In some experiments, chlorophyll levels were determined. One gram of tissue was collected from the lower leaf blades, and chlorophyll was extracted with 80% acetone and determined according to the technique of Arnon (2). Chlorophyll was expressed as milligrams per 100 grams of leaf tissue.

Experiment 1. 'Goddess' and 'Conquistador' kalanchoe plants were placed in chambers in a laboratory maintained at 23.5 ± 1°C. Plants were held in light (1.3 klx/12 hr/day) or in darkness in air ± 0.5 ppm ethylene for 2 days.

Experiment 2. 'Goddess' and 'Conquistador' plants were placed in chambers held in darkness in incubators maintained at 23, 28, and 33 ± 0.5°C. Each chamber contained air ± 0.5 ppm ethylene. The numbers of chlorotic leaves and chlorophyll content in plants were determined after a 3-day exposure.

Experiment 3. 'Tabasco' plants were held for 2 and 3

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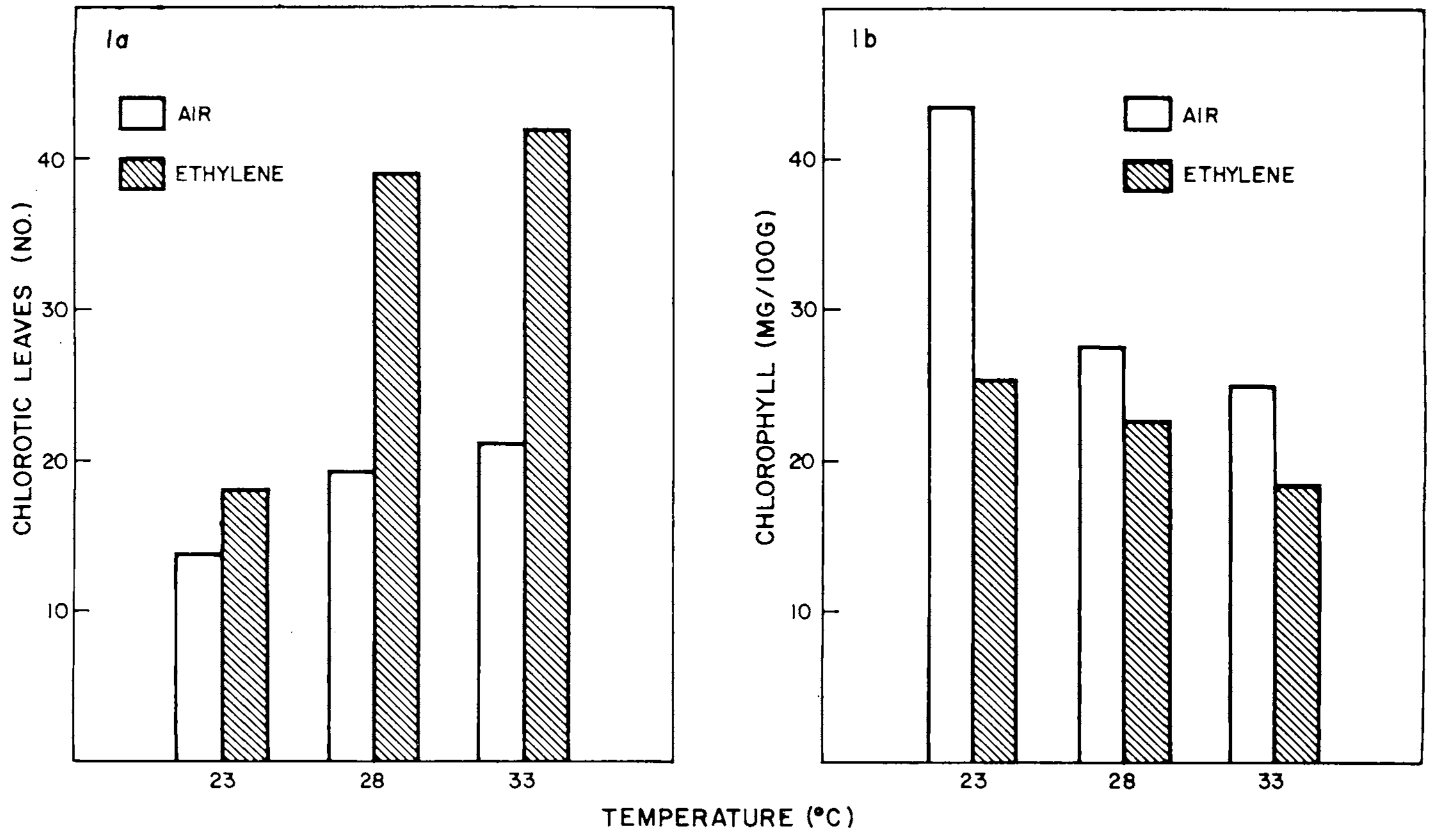

Fig. 1. (a) Number of chlorotic leaves of 'Goddess' kalanchoe plants exposed to air (y = −3.0 + 0.75x) or 0.5 ppm ethylene (y = −36.5 + 2.48x) and (b) chlorophyll content of 'Goddess' plants exposed to air (y = 83.6 − 1.84x) or 0.5 ppm ethylene (y = 41.3 − 0.68x) at various temperatures for 3 days in darkness.

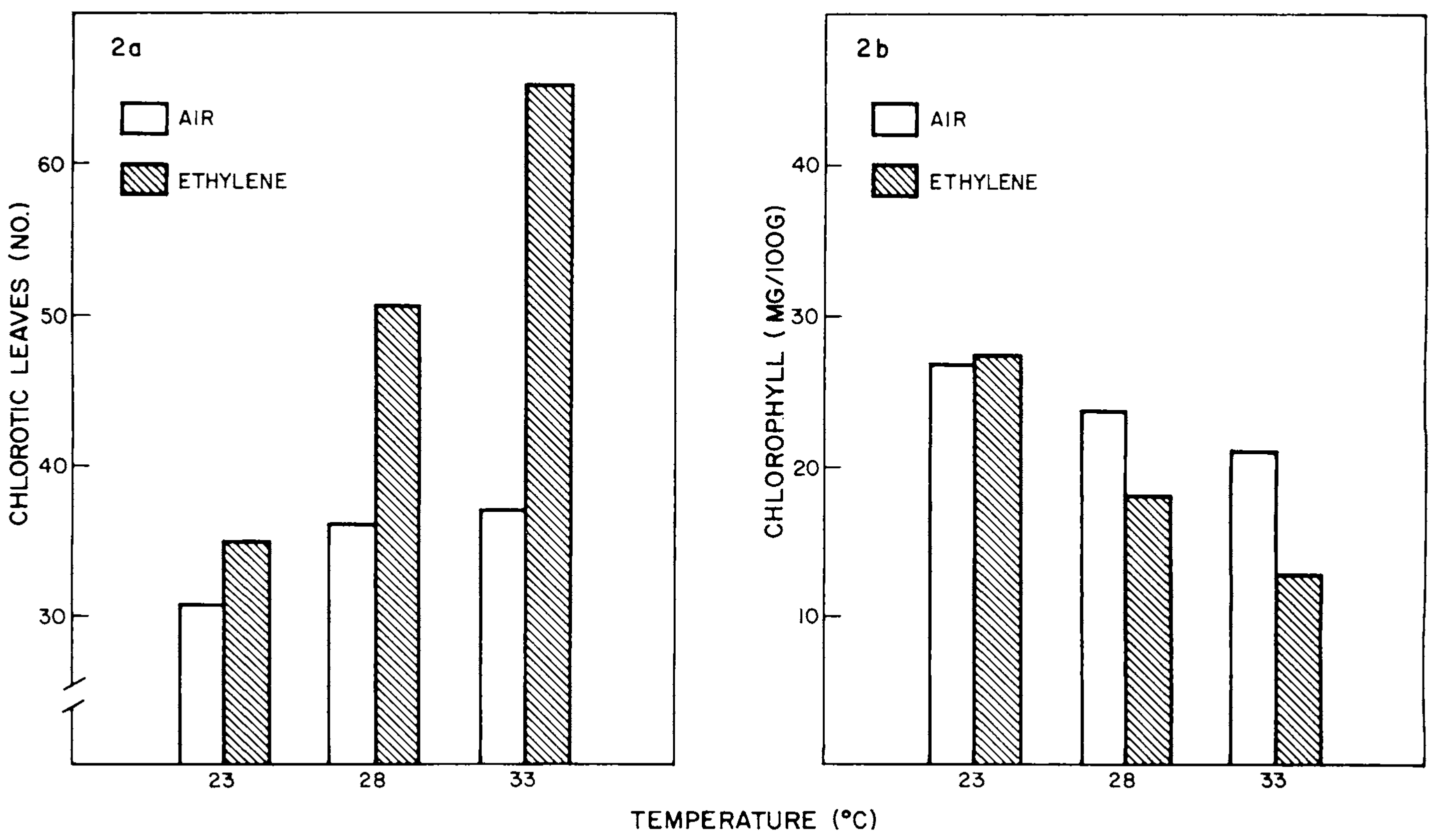

Fig. 2. (a) Number of chlorotic leaves of 'Conquistador' kalanchoe plants exposed to air (y = 20.1 + 0.53x) or 0.5 ppm ethylene (y = −34.5 + 3.03x) and (b) chlorophyll content of 'Conquistador' plants exposed to air (y = 40.3 − 0.59x) or 0.5 ppm ethylene (y = 59.1 −1.42x) at various temperatures for 3 days in darkness.

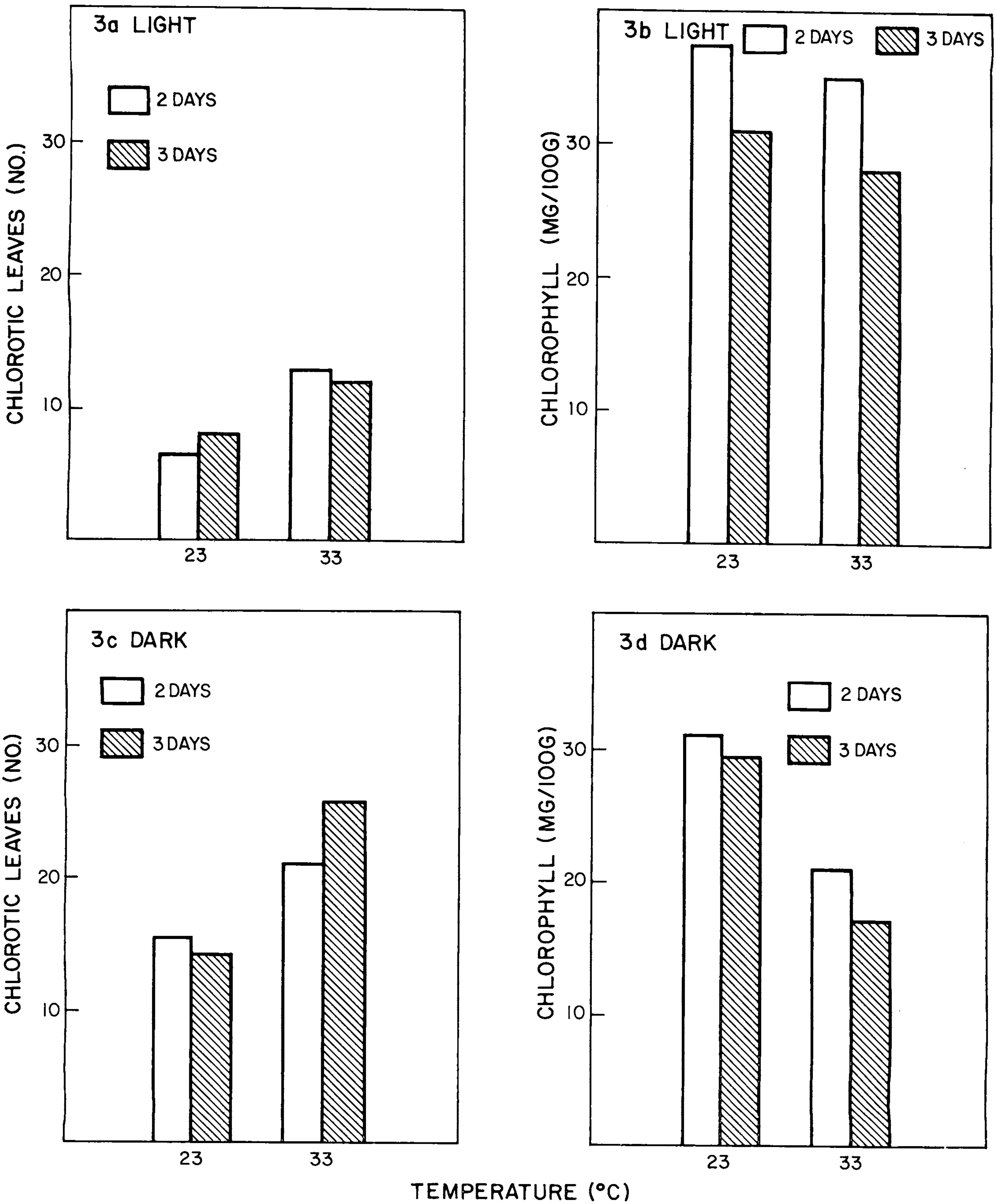

Fig. 3. Number of chlorotic leaves (a and c) and chlorophyll content (b and d) of 'Tabasco' kalanchoe plants held in light (a and b) and darkness (c and d) for 2 and 3 days at 23 and 33°C. Light and temperature main effects for number of chlorotic leaves were significant at the 1% level. Light, temperature, and time main effects on chlorophyll content were significant at the 1% level.

days in lighted or dark incubators maintained at 23 or 33°. Illuminance (0.4 klx) was maintained for 9 hr daily by cool-white fluorescent tubes. White cheesecloth was used to reduce the slightly higher illuminance in the incubator maintained at 33° to make it equivalent to the illuminance at 23°.

Results

Experiment 1. Plants held in light (1.3 klx for 12 hr/day) for 2 days at 23° did not become chlorotic, whereas those held in darkness were severely chlorotic (Table 1). Ethylene increased the number of chlorotic leaves on 'Goddess' plants held in darkness but did not do so for leaves of 'Conquistador' plants. Ethylene had no effect on number of chlorotic leaves on 'Goddess' and 'Conquistador' plants held in light.

Experiment 2. Plants held in air in darkness had fewer chlorotic leaves and contained more chlorophyll than did those held in air + ethylene in darkness (Fig. 1 and 2). With each successive increase in temperature, 'Goddess' and 'Conquistador' plants held in air ± ethylene had increased chlorosis and decreased chlorophyll levels. However, the rate of change for the increase in number of chlorotic leaves with increasing temperatures from 23 to 28° was greater for plants held in ethylene in darkness than for those held in air in darkness. 'Conquistador' plants had more chlorotic leaves and contained less chlorophyll than did 'Goddess' plants.

Experiment 3. 'Tabasco' kalanchoe plants held in low light (0.4 klx for 9 hr/day) for 2 and 3 days had fewer chlorotic leaves and contained more chlorophyll than did plants held in darkness (Fig. 3). Plants held at 23° for 2 and 3 days had fewer chlorotic leaves and contained more chlorophyll than those held at 33°. Plants held in low light or darkness for 3 days did not have a significantly different number of chlorotic leaves than those held for 2 days. However, plants held in low light or darkness for 3 days contained less chlorophyll than did those held for 2 days.

Discussion

The principal environmental factor causing leaf chlorosis in kalanchoe plants was darkness or low light intensity (Table 1, Fig. 3). Darkness (3, 7) and ethylene toxicity (1) are recognized as environmental factors responsible for leaf chlorosis and loss of chlorophyll during plant shipment. In *Philodendron*, leaf chlorosis and abscission increased in plants held in ethylene in light more than in plants held in ethylene in darkness (6). However, the mechanism for loss of chlorophyll in kalanchoe plants induced by ethylene in darkness may be different than that in *Philodendron* or other foliage plants, for the stomata of kalanchoes remain open in the dark. Kalanchoes are members of the Crassulaceae, which have metabolic processes referred to as crassulacean acid metabolism. In this process, the stomata open in the dark, CO_2 is fixed, and organic acids accumulate (4). Kalanchoe plants held in light in air + 0.5 ppm ethylene were not injured, presumably because ethylene could not enter the closed stomata. This physiological phenomenon in kalanchoe may be of practical significance. First, kalanchoe plants packaged for shipment (in a dark environment) and held at a warm temperature would be vulnerable to chlorophyll loss and leaf chlorosis. Next, the incidence of chlorosis would increase if packaged plants were exposed to ethylene. Lastly, the incidence of leaf chlorosis would increase as the exposure time and/or temperature increased. Hence, plants in sealed packages at an uncontrolled high temperature (33°) would become chlorotic within a 2-day shipping period. At present, kalanchoe plants are air-shipped from Florida with no provision for temperature control. In summer, ambient air temperatures are 30-35°. Thus, plants in packages (in darkness) on air terminal sidings during summer months can become chlorotic during the transit and shipping period.

Table 1. The number of chlorotic leaves on 2 cultivars of kalanchoe plants exposed to air + ethylene in 1.3 klx light or darkness for 2 days at 23.5°C.[z]

Light or darkness	Ethylene level (ppm)	Number of chlorotic leaves/plant		
		Conquistador	Goddess	Mean
Light	0	0	0	0
Darkness	0	9.0	6.0	7.5
Light	0.5	0	0.3	0.2
Darkness	0.5	9.7	12.0	10.9
Cultivar means		4.7	4.6	

[z]The main effects of light, ethylene, ethylene x cultivar, and light x ethylene x cultivar were significant at the 5% level.

Specific recommendations can not be made on methods to control leaf chlorosis in kalanchoe plants during transit, but some suggestions are offered below. Additional experimentation is needed before detailed recommendations can be made. Proper temperature control during shipment is one variable that needs further study. Flowering kalanchoe plants held at 10° in darkness in air for 3 days did not have chlorotic foliage or sleepy florets (5). We suggest that proper temperature control may possibly be used to prevent leaf chlorosis in young plants. At present, packaging plants for as short a period as possible, transporting them to market rapidly, and reducing or limiting exposure of plants to high temperature should help reduce the incidence of chlorosis.

Literature Cited

1. Abeles, F. B. Ethylene in plant biology. Academic Press, N.Y. 1973.
2. Arnon, D. I. 1949. Enzymes in isolated chloroplast polyphenoloxidase in *Beta vulgaris*. *Plant Physiol.* 24:1-15.
3. Conover, C. A. 1976. Postharvest handling of rooted and unrooted cuttings of tropical ornamentals. *HortScience* 11:127-128.
4. Laetsch, W. M. 1974. The C-4 syndrome: A structural analyses. *Ann. Rev. Plant Physiol.* 25:27-52.
5. Marousky, F. J. and B. K. Harbaugh. 1979. Ethylene-induced floret sleepiness in *Kalanchoe blossfeldiana* Poelln. *HortScience* 14:505-507.
6. ———— and ————. 1979. Interactions of ethylene and various environmental factors on leaf abscission in *Philodendron scandens* subs *oxycardium*. *J. Amer. Soc. Hort. Sci.* 104:876-880.
7. ———— and ————. 1980. Influence of temperature, light and ethylene on geranium (*Pelargonium hortorum* Bailey) seedlings during simulated shipping conditions. *J. Amer. Soc. Hort. Sci.* Submitted for publication.
8. Nell, T. A. and T. J. Sheehan. 1978. Kalanchoe—a potential new pot crop for Florida. *Proc. Fl. State Hort. Soc.* 91:222-223.
9. Nightingale, A. E. 1970. The influence of succinamic acid 2,2-dimethylhydrazide on the growth and flowering of pinched vs unpinched plants of the Kalanchoe hybrid 'Mace'. *J. Amer. Soc. Hort. Sci.* 95:273-276.
10. Pertuit, A. J., Jr. 1977. Influence of temperatures during long-night exposures on growth and flowering of 'Mace,' 'Thor,' and 'Telstar' Kalanchoe. *HortScience* 12:48-49.
11. Sheehan, T. J., and T. A. Nell. 1979. Kalanchoe yellow leaf—a problem and possible solutions. *HortScience* 14(3):276. (Abstr.).