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Enhancement of Peroxyacetyl Nitrate Injury to Petunia Foliage by Benomyl[1]

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Abstract. **The response of 'White Cascade' and 'Coral Magic' petunia (*Petunia hybrida* Vilm. -Andr.) plants to peroxyactyl nitrate (PAN) was tested 7 days after application of soil drenches of 0, 20, 40, 60, 80, 100, 120 μg benomyl/g dry weight of soil. The susceptible 'White Cascade', showed increased sensitivity to 745 μg/m^3 PAN for 1.5 hr when soil was treated with benomyl levels of 60 μg/g soil or greater. Enhanced foilar response to PAN was similar at all concentrations of benomyl greater than 60 μg/g soil. Foliage of 'White Cascade' petunias treated with concentrations of benomyl below 60 μg/g soil, responded to PAN similarly to plants which were not treated with the fungicide. The PAN sensitivity of the tolerant 'Coral Magic' was unaffected by benomyl application.**

Various researchers have documented the effectiveness of the systemic fungicide benomyl (methyl 1-(butylcarbamoyl)-2-benzimidazolecarbamate) in protecting plants from ozone injury (4, 5, 6, 7, 8, 9, 13). However, benomyl applications increased PAN toxicity on pinto bean (10) and 'White Cascade' petunia (11). In this study we further examine the response of petunia to PAN in the presence of benomyl. 'White Cascade' petunia was selected as the test plant because of the ability of benomyl to prevent ozone injury in this cultivar and its known susceptibility to PAN both in the field and laboratory (1, 2, 3).

Differential susceptibility and heritable nature of PAN susceptibility of petunia cultivars have been described (1, 2, 3). The ability of benomyl to influence the sensitivity of the PAN susceptible cultivar, 'White Cascade', and the tolerant cultivar 'Coral Magic', may have practical implications concerning the use of this fungicide as an antioxidant.

Petunia seeds were germinated in vermiculite and sprayed on alternate days with water or one-half strength complete Steiner's solution (15). Two weeks after germination, plants were transplanted to 7.5 cm diameter plastic pots containing a mixture composed of 2 sand: 1 Hagerstown silty clay loam soil (by volume) and were grown in a greenhouse. Experiments were conducted throughout the calendar year; supplemental lights provided a standard photoperiod of 14 hr light. The soil mix was watered with 10 ml of one-half strength Steiner's solution on alternate days. Twenty one days after the petunias were transplanted, a 10 ml soil drench of benomyl dissolved in distilled water was applied to each pot. In the first experiment 'White Cascade' petunias received 0, 60, 80, 100 or 120 μg benomyl/g dry weight of soil. In the second experiment 'White Cascade' and 'Coral Magic' petunias received 0, 20, 40, 60, 80, 100 or 120 μg benomyl/g dry weight of soil. Presence of benomyl in leaf tissue was verified at the time of exposure to PAN by a leaf disk bioassay method (12).

Plants were exposed to PAN in a modified growth chamber (20). All plants received a minimum 3 hr pre- and post-exposure to 38.8 klx of light to insure optimal plant sensitivity (16). Petunias were exposed to 745 μg/m^3 (0.15 ppm) or 993 μg/m^3 (0.20 ppm) PAN for 1.5 hr at 24°C and 75% relative humidity by methods previously described (14).

Plants were evaluated for PAN injury 96 hr after exposure. The bifacial necrosis on each leaf was evaluated on a scale of 0-100 where 0 = no injury, 10 = 1-10% injury, 20 = 11-20% injury, etc. The injury ratings for each leaf were summed and the total divided by the number of leaves per plant. There were 10 plants per treatment; individual experiments were replicated 2 or 3 times.

In the 1st series of experiments injury levels of benomyl treated 'White Cascade' petunias were significantly elevated from those of control plants. There were no differences in intensity of injury to plants receiving different concentrations of benomyl (Table 1).

In a 2nd experiment, there were no significant differences between PAN symptoms of control plants and those receiving 20 or 40 μg benomyl/g soil (Table 2). Peroxyacetyl nitrate injury of the foliage was stimulated at soil concentrations of benomyl of 60 μg/g soil. Higher levels of benomyl did not further enhance PAN toxicity.

Injury was so slight in 'Coral Magic' exposed to 745 μg/m^3 PAN with and without a benomyl application, that differential effects of the fungicide on symptom expression could not be observed. Similarly there were no differences in foliar injury of 'Coral Magic' treated with 0, 20, 40, 60, 80, 100, or 120 μg/g soil benomyl and subsequently exposed to 993 μg/m^3

Table 1. Effect of benomyl soil drench on visual injury rating of foilage of 'White Cascade' petunia plants exposed to 745 μg/m^3 (0.15 ppm) PAN for 1.5 hr.

Benomyl (μg/g soil)	Leaf surface injured[z] (%)
0	24 a[y]
60	40 b
80	37 b
100	39 b
120	36 b

[y]Each numerical value is the mean of 2 replications with 10 plants per treatment per replication. Mean separation by Waller and Duncan's modified (Bayesian) least significant difference test value (K = 100) 5% level (19).

[z]Each leaf was evaluated on a scale of 0-100 where 0 = no visible injury, 10 = 1-10% injury, etc. Injury ratings for each leaf were summed and the total divided by the number of leaves per plant.

Table 2. Determination of threshold concentration of benomyl responsible for stimulation of injury in 'White Cascade' petunia exposed to 745 μg/m^3 (0.15 ppm) PAN for 1.5 hr.

Benomyl (μg/g soil)	Leaf surface injured[z] (%)
0	41 a[y]
20	42 a
40	42 a
60	47 b
80	46 b
100	49 b
120	49 b

[y]Each numerical value is the mean of 3 replications with 10 plants per treatment per replication. Mean separation by Waller and Duncan's modified (Bayesian) Least significant difference test value (K = 100) 5% level (19).

[z]Each leaf was evaluated on a scale of 0-100 where 0 = no visible injury, 10 = 1-10% injury, etc. Injury ratings for each leaf were summed and the total divided by the number of leaves per plant.

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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.

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

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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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