N rate cultivar interaction was significant for yield in 1984 (Table 1). ‘Flo’ was the only cultivar showing a yield gain at the high N rate in 1984 with an increase from 7300 to 9300 kg ha⁻¹. The year × cultivar interaction was also significant and was expected since cultivars differ in their response to climatic conditions. The lack of yield response at the high N rate is a characteristic of Bush Blue Lake type cultivars (5).

Pod clustering and percentage of trash during harvest were not affected by N rate (Table 2). Pod clustering and percentage of trash were more severe in 1984 than in 1985. These factors were probably related to the availability of moisture during the harvest period in 1984.

More pods with decayed ends, primarily from touching the soil, were found at the high-N rate in 1984. This decay was a result of the increased lodging at the high-N rate and the wet soil and high humidity conditions during harvest in 1984. N rate × year and year × cultivar interactions were significant, illustrating the effect of rainfall and humidity on pod decay.

Cultivar significantly influenced every factor evaluated (Table 3). Highest plant stands involved ‘Bush Blue Lake 47’, ‘Labrador’, and ‘Sprite’, with ‘Labrador’ being the most productive cultivar in the trial and having less lodging than all cultivars except ‘Bush Blue Lake 47’. Pod clustering was more severe with ‘Peak’ than with all other cultivars, except ‘Sprite’ and ‘Bush Blue Lake 92’. More trash was harvested with ‘Strike’ than with any cultivar except ‘Atlantic’, with 7.3% decayed pods. The percentage of pod decay of these two cultivars was higher than the accepted standard levels.

The percentage of broken pods, pod length, and percentage of seed in pods averaged 13%, 15 cm, and 6.6%, respectively, and did not vary with N rate or year.

### Literature Cited


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### Abstract

Four cultivars of greenhouse cucumber (Cucumis sativus L. ‘Corona’, ‘Farbiola’, ‘Pandex’, and ‘Sandra’) were grown under four lighting conditions: natural light and natural light supplemented by 100, 200, or 300 μmol s⁻¹ m⁻² provided by high-pressure sodium lamps for a photoperiod of 18 hr. For this purpose, transplants were first seeded on 24 Sept. 1984, transplanted on 23 Oct., and grown according to the successive cropping method. Supplemental lighting enhanced plant growth and increased yield. Our data indicate that a marketable yield of 240 fruit/m² per year of greenhouse cucumbers could be obtained with supplementary lighting of 300 μmol s⁻¹ m⁻².

Cucumber plants require high levels of light in order to grow rapidly and produce heavily. In autumn and winter in northern latitudes, vegetative growth is retarded and the majority of young fruits abort. Low yields obtained under these conditions, in addition to high heating costs, do not allow profitable cropping. Consequently, greenhouse cucumber culture in northern areas is confined to spring and summer when light levels are high. Artificial lighting during the periods of low light intensity would lengthen the production season and permit year-round production.

Several research studies showed the benefits of supplementary lighting. Boivin et al. (5) reported that young tomato plants transplanted on 6 Feb. in Quebec and grown under supplementary light of 50, 100, and 150 μmol s⁻¹ m⁻² of photosynthetically active radiation (PAR) (400–700 nm) during the nursery period provided an increase in early yields (3 first weeks) of 19%, 31%, and 42%, respectively, in comparison with transplants grown under natural light only. Supplementary lighting allowed a significant increase in yields for a winter tomato greenhouse production (3, 8). Bacher and Hallig (2) observed that light supplied during the nursery period enabled production of vigorous cucumber transplants with dark green color and early production without increasing the total yield. Fluorescent lighting supplied during the production period tripled and even quadrupled November and December cucumber yields compared to those of control plants (7). Blom and Ingratta (4) exposed cucumber plants to an irradiance of 5.3 W m⁻² supplied by high-pressure sodium (HPS) lamps, and obtained an increase in yields of 7.8% and 6% for the spring and fall crop, respectively. These yield increases under their conditions were, however, insufficient to show the profitability of artificial lighting.

Hydro-generated electricity, an abundant renewable source of energy in Quebec, is available to greenhouse growers at a very low price. In order to benefit from this energy, researchers advocate the use of the highest irradiance that can be provided by supplementary lighting for the production of greenhouse vegetables (3). According to Klering (9), every 1% reduction in light penetration in a greenhouse leads to a 1% yield reduction. Therefore, any supplementary light energy supplied during unfavorable light conditions should increase yields. We studied the influence of four irradiance levels on the vegetative growth and yield of four greenhouse cucumber cultivars grown under Quebec climatic conditions.

The experiment was conducted in a 55-m² glasshouse compartment. Four cultivars—‘Corona’, ‘Sandra’, ‘Farbiola’, and ‘Pandex’—were submitted to four levels of irradiance: natural light and natural light supplemented by 100, 200, 300 μmol s⁻¹ m⁻² measured at 0.75 m below the lamps by a radiometer Li-185 from Lambda Instruments. Irradiance at bag height was 22, 51, and 98.5 μmol s⁻¹ m⁻², respectively. HPS lamps (400 or 1000 W) extended the photoperiod to 18 hr. The lights were turned on from 0430 to 0830 hr and from 30 min before sunset to 2230 hr. Lights were also on during cloudy days.

A split-plot design was used with two replications of the four lighting treatments as main plots and the four cultivars as subplots. An analysis of variance and a regression analysis were performed for all data. Each lighting treatment covered an area of 6 m²,
was composed of eight plants, and was separated by white opaque curtains to eliminate overlapping and improve light uniformity.

A sequence cropping method developed by Adamson and Maas (1) was used because its v-shape improves natural and artificial light penetration within the plant canopy. Plants were seeded every 2 weeks from Sept. 1984 through Oct. 1985 in 12.5-cm-diameter pots. Seedlings were grown for 4 weeks in the greenhouse under supplementary lighting of 92 μmol·s⁻¹·m⁻² provided by cool-white fluorescent lamps. Seedlings were transplanted at the four- to six-leaf stage into individual bags containing 30 liters of a substrate made of 1 peat moss : 1 vermiculite (v/v). The substrate was replaced at each successive planting in order to maintain physical and chemical properties from one planting to another. The annual production cycle commenced with the 23 Oct. 1984 planting and ended with the 1 Oct. 1985 planting.

Plants were fertilized with a complete nutrient solution (1) twice daily by means of a drip irrigation system until runoff. Air temperature at 1.80 m above the floor was maintained at 20° to 22°C at night and at 25° to 28° during the day. Root-zone temperature was only 18° to 20° due to air stratification in the greenhouse.

Yields were measured three times a week, starting on 10 Dec. 1984. Total yields for the four cultivars are considered. We used extra plants to measure vegetative growth for 'Sandra' and 'Farbiola' sown on 4 Jan. 1985 and transplanted in the greenhouse 2 Feb. 1985. Plant growth measurements were taken on 26 Feb. 1985, i.e., 24 days after transplanting or 53 days after seeding. Several parameters were measured—leaf area and number, stem length, and shoot dry weight.

Plant growth. Supplementary lighting enhanced growth of cucumber plants. The stem length and the number of fully formed leaves increased linearly when supplementary lighting increased from 0 to 300 μmol·s⁻¹·m⁻². Between 200 and 300 μmol·s⁻¹·m⁻², there were no significant differences for these two parameters. Supplementary lighting promoted more stem elongation of 'Sandra' than it did of 'Farbiola'. Supplementary lighting also increased leaf area and shoot dry weight (Table 1). Leaf area and shoot dry weight increased by 100% and 170%, respectively, for 'Sandra', whereas this increase was 50% and 83% for 'Farbiola' when light was supplemented at 300 μmol·s⁻¹·m⁻². This increased rate of vegetative growth might be explained by an increased photosynthetic activity of cucumber leaves submitted to higher irradiance (6). Rodriguez and Lambeth (10) reported an increase in the photosynthetic rate and the photosynthetic efficiency of tomato plants submitted to supplementary lighting. Those plants had developed a large photosynthetic capacity to supply the young growing fruits. The increased growth rate should produce noticeable early and total yields.

Yield. On average, plants treated with natural light and natural light supplemented with 100, 200, and 300 μmol·s⁻¹·m⁻² began producing on 29, 23, 13, and 10 Dec. 1984, respectively. Harvesting started 19 days earlier when cucumber plants received 300 μmol·s⁻¹·m⁻² of supplementary lighting over natural light only. Wilde (11) also reported early cucumber formation and ripening under supplementary lighting.

On 10 May 1985, five successive plantings contributed to the yields of the natural light and 100 μmol·s⁻¹·m⁻² treatments and six successive plantings contributed to those of 200 and 300 μmol·s⁻¹·m⁻² treatments; these data also indicate the fast growth rate of greenhouse cucumber grown with supplementary lighting. After 5 months, the mean total cumulative yields for the four cultivars evolved as follows: from the end of December to the end of February yields were three times higher under 300 μmol·s⁻¹·m⁻² than under natural light conditions. From the end of March to 10 May, the 300 μmol·s⁻¹·m⁻² treatment doubled yields as compared to the control. The yield increase diminished from three to two because of the increasing contribution of solar energy to the total light energy. After 5 months of harvest, the total cumulative yields for all cultivars were increased significantly by supplementary lighting (Fig. 1). Marketable yield/m² obtained with 300 μmol·s⁻¹·m⁻² were increased over the control from 34 to 50 fruit (47%) for 'Sandra', 43 to 68 fruit (58%) for 'Pandex', 39 to 71 fruit (82%) for 'Corona', and 41 to 78 fruit (90%) for 'Farbiola'. An average of 67 marketable fruit/m² was obtained at that time, representing 160 marketable fruit/m² on a yearly basis.

The largest increase in yields occurred in December, January, and February when supplementary lighting had the highest contribution to the radiant energy supplied to cucumber plants. Analysis of variance indicated a significant interaction between cultivars and supplementary lighting. Response to supplementary lighting was linear for 'Sandra' and 'Farbiola' but linear and cubic for 'Corona' and 'Pandex'. The cubic effect resulted from a large increase in yields between 100 and 200 μmol·s⁻¹·m⁻² and a very small increase between 0 and 100 or 200 and 300 μmol·s⁻¹·m⁻². The important increase in productivity occurring between 100 and 200 μmol·s⁻¹·m⁻² suggests the existence of an irradiance threshold, under which very little increase in yields can be achieved.
Supplementary lighting promoted plant growth of ‘Sandra’ and ‘Farbiola’ and accelerated production. The number of successive plantings thus was increased. Supplementary lighting of 300 μmol·s⁻¹·m⁻² increased productivity considerably. With the best cultivar (Farbiola), 78 marketable fruit/m² were obtained over a period of 5 months. On an annual basis, yields would reach 190 marketable fruit/m². With improved cultural practices and the optimization of environmental factors, higher yields could be reached. Supplementary lighting enables a continuous production cycle to supply the market with fresh cucumbers throughout the year.

This experiment has shown the potential of artificial lighting for the production of greenhouse cucumber. Further research should examine the effect of HPS lighting between 100 and 200 μmol·s⁻¹·m⁻² since two of the studied cultivars increased primarily within this range. Other cultivars should also be tested in order to identify those that are adapted to supplementary lighting.

### Literature Cited


### Daminozide Affects Growth and Yield of ‘Heritage’ Red Raspberry

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Additional index words. butanedioic acid mono-(2,2-dimethylhydrazide)

**Abstract.** Application of daminozide to young ‘Heritage’ primocanes significantly increased early yields by increasing the number of fruit that ripened on lower fruiting laterals. Daminozide at 2000 ppm applied to 30-cm-high primocanes would enable a commercial crop to be harvested in districts otherwise unsuitable for summer production. Chemical names used: butanedioic acid mono(2,2-dimethylhydrazide) (daminozide).

Primocane fruiting raspberries in some districts of southern Australia frequently do not achieve full production due to poor weather. In the major production areas, the cultivar Heritage can produce fruit from mid-February to the end of May. However, the onset of winter weather during the latter part of the season frequently arrests fruit development before full production is realized.

Crandall and Garth (4) showed that daminozide applied to 45-cm-high ‘Heritage’ primocanes increased yields in the first 16 days of production, and Braun and Garth (1) showed that daminozide applied to young ‘Heritage’ increased yields in the first month of production, but did not alter total yield over the harvest season.

The objectives of the present work were to: 1) evaluate the efficacy of daminozide under southern Australian conditions, and 2) examine the effects of daminozide on primocane growth and reproductive habit. The trial was conducted in a 2-year-old planting at the Potato Research Station, Healesville, Victoria (lat. 37°48’S, long. 145°30’E, alt. 602.9 m).

Small bundles of root pieces (about 60 g each [fresh weight]) were planted 80 cm apart in early Spring 1983. Emerging primocanes were pruned in Spring 1983 and 1984 to maintain stools of about 25 cm in diameter. This cultural system was applied specifically to create uniform discrete small units for experimental purposes. Rows were 3 m apart. Primocane numbers averaged 9.2 per stool, with no significant differences (analysis of variance) between treatments or blocks.

The experimental stools were selected during October as soon as primocane number and vigor could be assessed. The experiment was randomized complete block design with eight single stool replications per treatment. Daminozide (1000 and 2000 ppm plus 0.2% Agral 60 wetting agent) was sprayed to run-off when primocane height averaged 30, 45, and 60 cm. Control stools were sprayed with water plus wetting agent.

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<thead>
<tr>
<th>Primocane ht at application (cm)</th>
<th>Mean fruit yield (g/stool)</th>
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