Ethylene Gas for Defoliation of Hydrangeas

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Abstract. Summer-grown *Hydrangea macrophylla* subsp. *macrophylla* var. *macrophylla* (Thunb.) were exposed for 1 week to C_2H_4 at 0, 0.5, 2.0, 5.0, 50, or 500 $\mu\text{l}\cdot\text{liter}^{-1}$ in dark storage at 16C for defoliation before cold storage. The number of leaves remaining per shoot for all cultivars decreased with C_2H_4 concentration, and $>5 \mu\text{l } C_2H_4/\text{liter}$ was effective in defoliating 'Kasteln', 'Mathilda Gutges', and 'Todi' but not 'Merritt's Supreme'.

Field-grown florists' hydrangeas are normally defoliated before cold storage to reduce foliar diseases. Chemical defoliant have either no registration and a low LD_{50} or show negative side effects (Bailey, 1990; Kofranek and Leiser, 1958). As an C_2H_4 source, mature apples (3 liter apples/ m^3 of storage space) are effective for defoliating hydrangeas held in a fairly airtight enclosure. Because the optimal C_2H_4 concentration for hydrangea defoliation is unknown, we determined this quantity for defoliation and its effect on subsequent plant growth.

Materials and Methods

At the end of Oct. 1991 and 1992, summer-grown plants, in 1.6-liter pots, of four florists' hydrangea cultivars (Kasteln, Mathilda Gutges, Merritt's Supreme, and Todi) from two commercial growers (Gregory and Westbrook) in southern Ontario were taken from the field. Terminal flower bud development was at stage 5 (Litlere and Stromme, 1975) for all cultivars. The first week of November, plants were exposed for 1 week to C_2H_4 at 0, 0.5, 2.0, 5.0, 50, or 500 $\mu\text{l}\cdot\text{liter}^{-1}$ or sprayed once with 2-butyne-1,4-diol (butyne diol; BD) at 10 g·liter⁻¹. Two plants per cultivar and grower were placed in open totes stacked inside a 300-liter, 150- μm -thick, sealed polyethylene bag. Predetermined volumes of C_2H_4 were injected into each bag to obtain the appropriate treatment concentration, verified by a gas chromatography and adjusted daily. All bags contained hydrated lime for CO_2 removal. Oxygen and CO_2 concentrations were checked every second or third day with a portable CO_2 - O_2 analyzer (Nova 305; Hamilton, Canada). Compressed O_2 was added to the bag to obtain 20.8% O_2 , and CO_2 con-

centrations remained near 0%. The C_2H_4 -treated plants were held in one room, and nontreated (control) and BD-treated plants were held in a separate room. Both rooms were dark, ventilated with C_2H_4 -free air, and kept at $16.0 \pm 1.0\text{C}$.

Three days after the 1-week C_2H_4 exposure, the number of leaves ($>4 \text{ cm}$ in length) that had to be physically removed (remaining leaves) and the total number of shoots were recorded for each plant. Defoliation was considered effective if the remaining number of

leaves per shoot per plant was <1.0 . After leaf removal, plants were stored for 6 weeks in a room at $5.0 \pm 1.0\text{C}$ then moved to a double acrylic greenhouse in mid-January. Plants were placed randomly on a subirrigation system using troughs and fertigated with 0.75 g 18N-0P-10K-9Ca-1 Mg per liter at each watering. The hydrangeas were forced at 18–20C. At flowering (pollen shown on the true flowers), shoot length and leaf surface area of the upper most fully expanded leaf pair on two shoots and the diameter and number of mature (fully expanded and pigmented), immature (green), and aborted inflorescences per plant were determined. The experiment consisted of a completely randomized design with each bag as an experimental unit and was run twice. We analyzed the results as a split-plot experiment with year and replication as the main sources of variation; the C_2H_4 concentration, cultivar, and grower, and their interactions were the subplot variables. Regression curves for the C_2H_4 concentration and the contrast analysis between BD and C_2H_4 were determined for the variables.

Results and Discussion

As none of the interactions between the independent variables were significantly different, only the means of the main variables are presented (Table 1). The number of leaves

Table 1. Leaves remaining on four cultivars of field-grown hydrangeas from two growers after plants were exposed for 1 week to C_2H_4 or a single spray with BD and the effect of these chemicals on the number of mature and immature inflorescences per plant following 6 weeks at 5C then greenhouse forcing at 18–20C. Data represent means for two consecutive years.

Variable	Leaves remaining/shoot after C_2H_4 treatment ^a	No. mature inflorescences ^b	No. immature inflorescences ^b
Year			
1	1.72	4.50	0.67
2	1.46	4.63	0.56
$LD_{0.05}$	NS	NS	NS
Source			
Gregory	1.44	4.67	0.69
Westbrook	1.73	4.47	0.54
$LD_{0.05}$	0.17	NS	NS
Cultivar			
Kasteln	1.44	4.59	0.74
Mathilda Gutges	1.22	6.05	0.83
Merritt's Supreme	2.36	4.09	0.53
Todi	1.32	3.54	0.37
$LD_{0.05}$	0.24	0.35	0.28
Defoliant			
C_2H_4 ($\mu\text{l}\cdot\text{liter}^{-1}$)			
0 (control)	2.58	4.20	0.98
0.5	2.43	4.54	0.65
2	1.97	4.71	0.44
5	0.97	4.47	0.62
50	0.73	4.71	0.55
500	0.65	4.77	0.47
BD (g·liter ⁻¹)			
10	1.83	4.80	0.56
Significance ^c			
C_2H_4	L***Q***	NS	NS
C_2H_4 vs. BD	***	NS	NS
Control vs. C_2H_4	***	**	***

^aRemaining number of leaves ($>4.0 \text{ cm}$ long) were counted 3 days after the end of C_2H_4 treatment or 7 or 10 days after BD application.

^bAfter forcing at 18–20C.

^cL = linear; Q = quadratic.

NS, *, **, ***Nonsignificant or significant at $P \leq 0.05$, 0.01, or 0.001, respectively.

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remaining per shoot for all cultivars decreased with increasing C_2H_4 concentration ($y = 2.08 - 0.0318 \times \text{concentration} + 0.0000579 \times \text{concentration} \times \text{concentration}$). Ethylene at $25 \mu\text{l}\cdot\text{liter}^{-1}$ was effective in defoliating 'Kasteln', 'MathildaGutges', and 'Todi' but not 'Merritt's Supreme'. The calculated optimum concentration for defoliation was $275 \mu\text{l}\cdot\text{liter}^{-1}$. BD was less effective than C_2H_4 at $>5 \mu\text{l}\cdot\text{liter}^{-1}$. The plant source showed a small but significant difference and was due probably to the difference in maturity of the terminal buds.

Treatments of C_2H_4 reduced the number of immature inflorescences and increased that of mature inflorescences compared to the control

plants (Table 1). Ethylene did not affect flowering date, number of aborted inflorescences, leaf surface area, stem length, or flower diameter (data not shown). These results are contrary to studies in which ethephon resulted in reduced growth after forcing (Shanks, 1969; This and Buxton, 1976).

Thus, gaseous C_2H_4 at $5-10 \mu\text{l}\cdot\text{liter}^{-1}$ at 16°C for 1 week in darkness was an effective alternative to BD at $10 \text{ g}\cdot\text{liter}^{-1}$ or the use of apples for defoliating 'Kasteln', 'Mathilda Gutges', and 'Todi' at minimal cost, and there were no negative effects on plant quality after forcing. 'Merritt's Supreme' may require a longer exposure or a higher temperature during C_2H_4 treatment.

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