Phytotoxic Effects of Hypochlorous Acid, Chloramines, and Chlorine Dioxide in Irrigation Water Applied to Bedding and Vegetable Plants

CATHERINE MEEHAN DONOVAN
PAUL R. FISHER, AND JINSHENG HUANG

ENVIRONMENTAL HORTICULTURE DEPT., UNIVERSITY OF FLORIDA, GAINESVILLE, FL 32611-0670

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Introduction

- To avoid the transmission of waterborne pathogens many producers sanitize recycled irrigation water before reapplication to crops.
- Typical targeted rate is a concentration 2 $mg \cdot L^{-1}$ of sanitizing agent
- Previous research and grower experience has shown the potential for phytotoxicity when sanitizing agents including hypochlorous acid, chlorine dioxide, and chloramines are applied in irrigation water

Example of grower experienced phytotoxicity

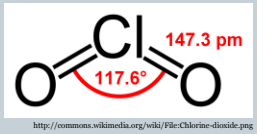
- 60 $mg \cdot L^{-1}$ chlorine accidentally applied with each drip irrigation to chrysanthemums

Sanitizing Agents

- Chlorine
  - Oxidizer and chlorination
  - Removes electrons from reagents and chlorine becomes reduced to chloride (Cl^-)
  - Forms hypochlorous acid (HOCl) in water, especially at pH levels below 7.5.

Sanitizing Agents

- Chlorine Dioxide
  - ClO_2
  - Oxidizer only
  - Remains a dissolved gas



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Sanitizing Agents

- Chloramines
  - Formed by a reaction of ammonia and HOCl
  - Solution may contain monochloramine (NH_2Cl), dichloramine ($NHCl_2$), or nitrogen trichloride (NCl_3)
  - More stable than HOCl
  - Longer residual effects, require longer contact time

Research Question

- Do sanitizing agents including hypochlorous acid (chlorine), chlorine dioxide, and chloramines have a phytotoxic effect on various plant species?
  - What are the symptoms?
  - What concentration is phytotoxic?
  - Which species are most sensitive?

Materials and Methods

- Chemical treatments:
  - Hypochlorous acid- from "Clorox" (sodium hypochlorite)
  - Chloramine- from "Clorox" (sodium hypochlorite) and ammonium hydroxide
  - Chlorine dioxide- from sodium chlorite and acid activator provided by ICA-TriNova LLC
  - Plus water control
- Up to 100 $mg \cdot L^{-1}$ of each sanitizer
- Up to 39 species of container-grown ornamental and vegetable plants

Materials and Methods: Trial One

- 1st trial: 0, 1, 2, 4, 8, or 16 $mg \cdot L^{-1}$
  - Three chemicals plus control
  - Three species (geranium, gomphrena, & viola)
  - Factorial design, randomized complete block
  - 4 blocks, 1 replicate per block
  - Each replicate was a partial 144-plug tray

Trial One

- 15 applications of 90 mL
- Applied once daily five times per week with battery-powered sprayer
- Measured dry mass, SPAD, pH/EC

Materials and Methods

- 2nd trial: 36 species 0 or 8 $mg \cdot L^{-1}$
  - 15 applications of 90 mL per partial 144-plug tray
  - Applied once daily five times per week with battery-powered sprayer
  - Measured dry mass, SPAD

Materials and Methods

- 3rd trial: 39 species 0 or 100 $mg \cdot L^{-1}$
  - Transplanted into 10 cm-diameter pots
  - Three applications to 39 species
  - 50mL applied once daily as a drench
  - Measured number of damaged leaves per plant

Results-Trial One

- There was no significant difference between chemical applications in either dry mass or SPAD chlorophyll index.
- No phytotoxic symptoms were observed in Pelargonium, Gomphrena, and Pansy, even at 16 mg·L^{-1} of the three sanitizers.

Results-Trial Two

- Phytotoxic symptoms were observed in certain cultivars at 8 mg·L^{-1} of either hypochlorous acid or chlorine dioxide
- No obvious damage was noted for the chloramine treatment in any species except for basil
- Bronzing or chlorosis were observed in the chlorine and chlorine dioxide treatments on the following cultivars:
  - *Ocimum basilicum* L. 'Genovese' basil
  - *Begonia obliqua* L. 'Baby Wing White' begonia
  - *Dianthus chinensis* × *barbatus* L. 'Floral Lace Purple' dianthus
  - *Lactuca sativa* L. 'Vulcan' and 'Green Star' lettuce
  - *Lobularia maritima* (L.) Desv. 'Clear Crystal White' alyssum.

Ocimum basilicum L. 'Genovese' basil

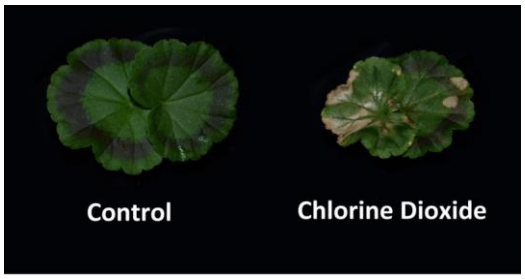
Begonia obliqua L. 'Baby Wing White' begonia

Results-Trial Three

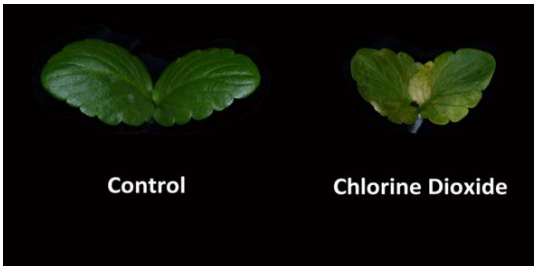
- There were significant main and interaction effects between species and sanitizer type ($p < 0.0001$)

Treatment	# of Bedding Species Significantly Affected	# of Vegetable Species Significantly Affected
100 mg·L^{-1} hypochlorous acid	1	1
100 mg·L^{-1} chloramine	1	1
100 mg·L^{-1} chlorine dioxide	20	5
Control	0	0

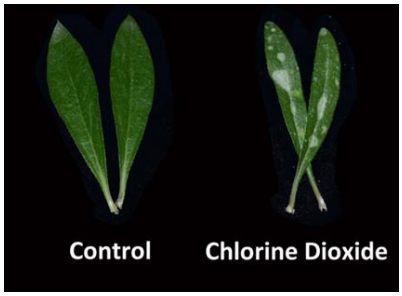
Pelargonium ×*hortorum* L. H. Bailey 'Ringo 2000 Deep Red' geranium



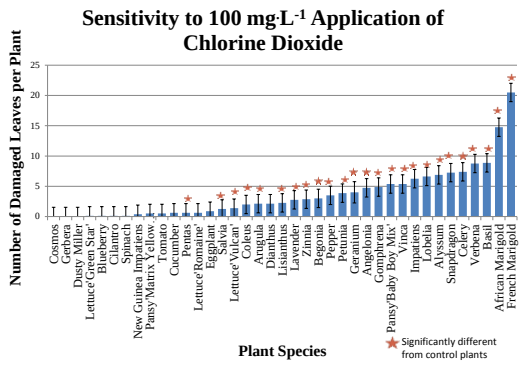
Viola× *wittrockiana* Gams 'Baby Boy Mix' pansy



Gomphrena sp. 'Fireworks' gomphrena



Glandularia ×*hybrida* (hort. ex Groenl. & Rümpler) G. L. Nesom & Pruski 'Quartz XP White' verbena



Conclusions

- A very high rate (100 mg·L^{-1}) of hypochlorous acid or chlorine dioxide caused phytotoxicity in the majority of bedding and vegetable plants tested
- Phytotoxicity was only observed in two species at the highest level of chloramine
- There are risks associated with the use of chlorine and chlorine dioxide sanitizing agents, especially at high concentration

Conclusions

- We may have observed low levels of phytotoxicity in our trial at 1 to 16 mg·L^{-1} because of applying solutions only once daily, and because of rapid drying on foliage
- Other conditions, such as mist application with high humidity and high applied water volumes, may cause greater damage

Conclusions

- What should growers do to avoid phytotoxicity:
  - Monitor
  - Maintain
  - Math

Thank You

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