Bitterlin, M.W., D. Gonsalves, and J.N. Cummins. 1984. Irregular distribution of tomato ringspot virus in apple trees. Plant Dis. 68(7):567–71.

Bitterlin, M.W., D. Gonsalves, and R. Scorza. 1987. Improved mechanical transmission of tomato ringspot virus to *Prunus* seedlings. Phytopathology 77(4):560–63.

Clark, M.F. 1981. Immunosorbent assays in plant pathology. Annu. Rev. Phytopathol. 19:83–106.

Cummins, J.N. and D. Gonsalves. 1986a. Constriction and decline of 'Stanley' prune associated with tomato ringspot virus. J. Amer. Soc. Hort. Sci. 111(2):315–318.

Cummins, J.N. and D. Gonsalves. 1986b. Irregular distribution of tomato ringspot virus at the graft unions of naturally infected Stanley plum trees. Plant Dis. 70(3):257–258.

Hadidi, A. and R.W. Hammond. 1989. Construction of molecular clones for identification and detection of tomato ringspot and arabis mosaic viruses. Acta Hort. 235:223–230.

Hoy, J.W. and S.M. Mircetich. 1984. Prune brownline disease: Susceptibility of prune rootstocks and tomato ringspot virus detection. Phytopathology 74(3):272–276.

Hoy, J.W. S.M. Mircetich, and B.F. Lownsbery. 1984. Differential transmission of Prunus tomato ringspot virus strains by Xiphinema californicum. Phytopathology 74(3):332–335.

Lister, R.M., W.R. Allen, D. Gonsalves, A.R. Gotlieb, C.A. Powell, and R.F. Stouffer. 1980. Detection of tomato ringspot virus in apple and peach by ELISA. Acta Phytopathol. Acad. Sci. Hungaricae 15(1-4):47–55.

Little, T.M. and F.J. Hills. 1975. Analysis of counts, p. 193–198. In. Statistical methods in agricultural research. Univ. of California Press. Davis.

Mircetich, S.M. and J.W. Hoy. 1981. Brownline of prune trees, a disease associated with tomato ringspot virus infection of Myrobalan and peach rootstocks. Phytopathology 71(1):30–35.

Powell, C.A., A. Hadidi, and J.M. Halbrendt. 1991. Detection of tomato ringspot virus in nectarine trees using ELISA and transcribed RNA probes. HortScience 26(10):1290–1292.

Rezaian, M.A. and L.K. Krake. 1987. Nucleic acid extraction and virus detection in grapevine. J. Virol. Methods 17:277–285.

Ramsdell, D.C., V.A. Adler, and C.R. Kesner. 1993. Prune brown line disease occurrence in declining 'Stanley' plum orchards in Michigan and factors related to its incidence. HortTechnology 3(3): 325–329.

Stace-Smith, R. 1984. Tomato ringspot virus. Description of plant viruses. No 290. Commonwealth Mycol. Inst.–Assn. Applied Biol. Kew, Surrey, England.

Stace-Smith, R. and D.C. Ramsdell. 1987. Nepoviruses of the Americas, p. 131–165. In. K.F. Harris (ed.). Current topics in vector research. vol 3. Springer-Verlag, New York.

Teliz, D., R.G. Grogan, and B.F. Lownsbery. 1966. Transmission of tomato ringspot, peach yellow bud mosaic, and grape yellow vein viruses by Xiphinema americanum. Phytopathology 56:658–663.

Teliz, D., B.F. Lownsbery, R.G. Grogan, and X.X. Kimble. 1967. Transmission of peach yellow bud mosaic virus to peach, apricot, and plum by *Xiphinema americanum*. Plant Dis. Rpt. 51(10):841–843.

Chemical Treatments to Control *Erwinia* Soft Rot of Calla Rhizomes

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Additional index words. *Zantedeschia*, calla lily, *Erwinia*, soft rot

Summary. Dimethyl ammonium chloride (DAC, 'Triathlon'), sodium hypochlorite, formaldehyde, and streptomycin ('Agri-mycin 17') were used as dips to treat *Zantedeschia rehmannii superba* Engl., *Zantedeschia elliotiana* ×*maculata* (Hook.) Engl., and *Zantedeschia albomaculata* (W.Wats.) Baill. rhizomes to control *Erwinia* soft rot. A 30 min 200 ppm ($mg \cdot L^{-1}$) streptomycin dip provided the best control of *Erwinia* soft rot for all three *Zantedeschia* species and a 1-hour 10% formaldehyde dip provided the second best control of inoculated rhizomes. Rhizomes inoculated with *Erwinia* required more days to emerge. Chemical treatments did not affect days to emergence or final plant growth.

Bacterial soft rot, caused by *Erwinia carotovora* subsp. *carotovora* (Jones) Bergey et al. (*Ecc*) is a major limiting factor in calla forcing and causes *Zantedeschia*

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Table 1. Chemical treatments used on *Zantedeschia* rhizomes for control of *Erwinia carotovora* subsp. *carotovora* in Expts. 1 and 2.

Chemical treatment
Experiment 1
Control[z]
No treatment[y]
5% Dimethyl ammonium chloride[x] (DAC) dip for 10 min
10% Bleach[w] dip for 10 min
4% Formaldehyde[v] dip for 1 h
100 ppm Streptomycin[u] dip for 30 min
Experiment 2
Control
No treatment
5% DAC dip for 10 min
5% DAC dip for 30 min
10% Clorox dip for 10 min
20% Clorox dip for 10 min
4% Formaldehyde dip for 1 h
10% Formaldehyde dip for 1 h
100 ppm Streptomycin dip for 30 min
200 ppm Streptomycin dip for 30 min

[z]Control = no pierce, no inoculation, no chemical treatment or deionized water dip.
[y]No treatment = pierced, no chemical treatment dip, 10 min deionized water dip.
[x]Triathlon; Olympic Horticultural Products, Mainland, Pa.
[w]5.25% Sodium hypochlorite as bleach.
[v]Formaldehyde; Fisher Scientific, Fairlawn, N.J.
[u]Agri-mycin 17; Merk & Co., Rathway, N.J.

plants to turn yellow; creates a foul smelling rot of rhizomes, leaves, and flower stems; and causes plants to decline rapidly (Corr, 1990; Tjia, 1985). *Ecc* infection is greatest when day and night temperatures are high (>80 °F or >27 °C) and the medium remains too wet. Current methods used to prevent or reduce *Ecc* soft rot are discarding diseased rhizomes before planting, growing plants at moderate temperatures (≤75 °F or ≤24 °C), providing well-drained medium, avoiding overwatering, and using a preventive fungicide program. Previous observations indicated that rhizomes treated with sodium hypochlorite, streptomycin, and cloramphenicol could reduce *Ecc* incidence (Tjia and Jierwiriyipant, 1988). No quantitative data, however, were recorded. Hot water treatments were found to be ineffective for control of *Ecc* on *Zantedeschia* (Corr, 1993). Since it is often difficult to determine levels of *Ecc* infection before planting, the objective of this research was to determine the efficacy of chemical treatments of calla rhizomes for preventing or decreasing incidence of *Ecc* soft rot.

Materials and methods

Zantedeschia rehmannii superba (pink flowers), *Zantedeschia elliotiana* ×*maculata* (yellow flowers), and *Zantedeschia albomaculata* (white flowers) rhizomes were used in two separate experiments. *Ecc* isolates were obtained from infected calla rhizomes and identified using the Biolog Microplate system (Biolog, Hayward, Calif.). For each treatment, twelve rhizomes of each species were inoculated with *Ecc* by piercing four times with a needle to a depth of 1.4 inch (3.5 cm), followed by a 10-min dip in *Ecc* inoculum (10^4 cells/mL suspended in deionized water) and then were allowed to air dry 24 h before treatment application. For each treatment, another set of 12 rhizomes of each species was pierced with a needle as described above and dipped in deionized (DI) water for 10 min. The pierced, noninoculated rhizomes were added to the experiment so that the piercing of the rhizomes (wounding) was not a confounding factor in the experiments. Chemical treatments are listed in Table 1 for Expts. 1 and 2.

Rhizomes of each *Zantedeschia species* were planted individually into 6-inch (15-cm) standard pots using a 0.33 peat : 0.33 pine bark : 0.16 sand : 0.16 perlite growing medium. Plants were grown in a greenhouse with a setpoint of 75/64 °F (24/18 °C) day/night and arranged in a completely randomized design. A tank mix of Metalaxyl 2E [0.13 fl. oz/gal (0.16 mL·L^{-1})] and Quintozene 75% W.P. [0.08 oz/gal (0.6 g·L^{-1})] was applied as a drench after planting. Plants were fertilized with a commercial 20N–4.4P–16.6K water soluble fertilizer (Scotts 20–10–20 Peat Lite Special, The Scotts Co., Marysville, Ohio) at 300 ppm (mg·L^{-1}) N, which was applied at each irrigation.

Plants were monitored for development of characteristic *Ecc* soft rot symptoms such as shoot and foliage

Table 2. Percentage of infected plants from inoculated and noninoculated rhizomes with preplant chemical treatments for control of *Erwinia carotovora* subsp. *carotovora* (*Ecc*) on *Zantedeschia rehmannii* superba (*Zrs*), *Z. albomaculata* (*Zam*), and *Z. elliotiana* ×*maculata* (*Zem*) during Expt. 1.

Treatment	*Ecc* inoculation (% infected plants)			No *Ecc* inoculation (% infected plants)		
	Zrs	*Zam*	*Zem*	*Zrs*	*Zam*	*Zem*
Control[z]	---	---	---	17	0	50
No treatment[y]	83	67	83	8	0	0
5% DAC dip for 10 min	67	67	100	0	0	0
10% Bleach dip for 10 min	75	75	92	17	0	0
4% Formaldehyde dip for 1 h	50	50	50	0	0	0
100 ppm Streptomycin dip for 30 min	8	0	50	0	0	0

[z]Control = no pierce, no inoculation, no chemical treatment or deionized water dip.
[y]No treatment = pierced, no chemical treatment dip, 10 min deionized water dip.

Table 3. The effect of chemical treatment of rhizomes on days to emergence of *Zantedeschia rehmannii* superba (*Zrs*), *Z. albomaculata* (*Zam*), and *Z. elliotiana* ×*maculata* (*Zem*) for Expt. 1.

Treatment	Days to emergence		
	Zrs	*Zam*	*Zem*
Inoculation			
No treatment[z]	9 ± 3.2 ab[y]	11 ± 3.2 b	13 ± 4.2 a
5% DAC 10 min	11 ± 3.5 a	12 ± 4.3 b	9 ± 4.1 bc
10% Bleach	8 ± 1.9 b	10 ± 4.7 b	11 ± 4.7 abc
4% Formaldehyde	10 ± 2.7 ab	20 ± 5.6 a	12 ± 4.9 ab
100 ppm Streptomycin	8 ± 2.6 b	8 ± 3.6 b	8 ± 3.9 c
No inoculation			
Control[x]	8 ± 1.2 bc	5 ± 2.4 bc	8 ± 4.6 a
No treatment	10 ± 2.5 ab	8 ± 4.1 ab	6 ± 3.1 ab
5% DAC	7 ± 2.2 dc	5 ± 2.2 c	7 ± 3.5 ab
10% Bleach	6 ± 3.2 d	6 ± 3.5 abc	5 ± 2.8 b
4% Formaldehyde	9 ± 2.4 ab	8 ± 3.6 a	9 ± 4.0 a
100 ppm Streptomycin	6 ± 1.5 d	6 ± 3.1 abc	5 ± 2.6 b

[z]No treatment = pierced, no chemical treatment dip, 10 min deionized water dip.
[y]Mean separation within columns by Duncan's multiple range test, $P = 0.05$.
[x]Control = no pierce, no inoculation, no chemical treatment or deionized water dip.

yellowing, wilt, and rhizome rot. The number of plants that were infected with *Ecc* (exhibiting symptoms of soft rot) were recorded for 65 d, after which time the experiments were terminated. Because the plants were either infected or not infected, the data had a binomial distribution. Therefore a logistic analysis (PROC CATMOD; SAS Institute, Cary, N.C.) was applied to the data and a set of contrasts was used to compare data for all treatments against the data for the 100 ppm streptomycin treatment (Expt. 1) or 200 ppm streptomycin treatment (Expt. 2). The reason for using the data for the 100 and 200 ppm streptomycin treatments for comparison was because these treatments provided the best control for both experiments. Thus, they were used as the base for comparison of data among treatments (Tables 2 and 4). The number of days from planting of rhizomes to emergence of shoots was termed days to emergence (DTE). Days to emergence was recorded for all treatments. ANOVA was used to test for treatment effects on DTE and mean differences were determined by Duncan's multiple range test (PROC GLM; SAS).

Results and discussion

EXPERIMENT 1. *Z. rehmannii superba* and *Z. elliotiana* ×*maculata* were the most susceptible to *Ecc* soft rot as indicated by 83% infection of those plants inoculated and not chemically treated and 17% and 50% (respectively) infected control plants (Table 2). Percent infection ranged from 50% to 100% across cultivars for other preventive treatments. Streptomycin at 100 ppm provided the best control of *Ecc* infection for all three species with *Erwinia* infection of 0% *Z. albo maculata*, 8% *Z. rehmannii superba*, and 50% *Z. elliotiana*×*maculata*. A 4% formaldehyde dip provided the second best control of *Ecc* with a 50% infection of rhizomes.

For all three species, most *Zantedeschia* rhizomes inoculated with *Ecc* took longer to emerge than the corresponding rhizomes that were not inoculated (Table 3). Wounding did lengthen the time to emergence of two *Zantedeschia* species, but not significantly. While most control rhizomes took more days to emerge than those chemically treated, those treated with 4% formaldehyde showed delayed emergence when compared to the control.

EXPERIMENT 2. Because only one treatment completely overcame the *Ecc* inoculation (100 ppm streptomycin dip of *Z. ablo maculata*) in Expt. 1, a second experiment (Table 1) was conducted to replicate the first experiment and the time or rate of application of chemical treatments was increased.

Streptomycin at 200 ppm provided the best control of *Ecc* for the inoculated plants in the second experiment while formaldehyde provided second best control (Table 4). Bleach treatments and 4% formaldehyde provided the best control of *Ecc* of noninoculated plants, while streptomycin provided the second best con-

Table 4. Percentage of infected plants from inoculated and noninoculated rhizomes with preplant chemical treatments for control of Erwinia carotovora subsp. carotovora on *Zantedeschia rehmannii superba* (*Zrs*), *Z. albomaculata* (*Zam*), and *Z. elliotiana* ×*maculata* (*Zem*) during Expt. 2.

Treatment	Inoculation (% infected plants)			No inoculation (% infected plants)		
	Zrs	*Zam*	*Zem*	*Zrs*	*Zam*	*Zem*
Control[z]	---	---	---	8	100	67
No treatment[y]	100	83	83	0	92	67
5% DAC dip for 10 min	100	92	100	0	25	8
5% DAC dip for 30 min	100	92	100	0	0	25
10% Bleach dip for 10 min	100	67	92	0	8	0
20% Bleach dip for 10 min	100	83	100	0	8	0
4% Formaldehyde dip for 1 h	92	92	92	0	0	0
10% Formaldehyde dip for 1 h	75	75	100	8	0	0
100 ppm Streptomycin dip for 30 min	92	0	83	42	0	0
200 ppm Streptomycin dip for 30 min	67	8	58	25	0	8

[z]Control = no pierce, no inoculation, no chemical treatment or deionized water dip.
[y]No treatment = pierced, no chemical treatment dip, 10 min deionized water dip.

Table 5. The effect of chemical treatment of rhizomes on days to emergence of Zantedeschia rehmannii superba (*Zrs*), *Z. albomaculata* (*Zam*), and *Z. elliotiana* ×*maculata* (*Zem*) for Expt. 2.

Treatment	Days to emergence		
	Zrs	*Zam*	*Zem*
Inoculation			
No treatment[z]	11 ± 3.8 ab[y]	10 ± 2.1 b	13 ± 3.9 a
5% DAC 10 min	12 ± 4.2 ab	11 ± 2.8 b	9 ± 3.6 a
5% DAC 30 min	13 ± 6.3 ab	13 ± 3.3 b	11 ± 0.7 a
10% Bleach	10 ± 2.9 b	11 ± 2.1 b	13 ± 4.9 a
20% Bleach	10 ± 1.8 b	11 ± 1.6 b	12 ± 4.9 a
4% Formaldehyde	11 ± 3.8 ab	13 ± 3.2 b	11 ± 4.1 a
10% Formaldehyde	15 ± 9.3 a	17 ± 6.1 a	14 ± 5.6 a
100 ppm Streptomycin	9 ± 3.4 b	12 ± 3.1 b	10 ± 2.9 a
200 ppm Streptomycin	10 ± 3.7 ab	11 ± 2.7 b	10 ± 4.2 a
No inoculation			
Control[x]	8 ± 1.6 a	8 ± 1.1 c	9 ± 2.4 b
No treatment	8 ± 2.8 a	10 ± 2.5 bc	9 ± 2.1 b
5% DAC 10 min	9 ± 1.9 a	9 ± 1.5 bc	12 ± 5.1 b
5% DAC 30 min	10 ± 1.8 a	10 ± 2.9 bc	9 ± 1.9 b
10% Bleach	8 ± 1.6 a	8 ± 2.1 c	9 ± 2.2 b
20% Bleach	9 ± 1.5 a	11 ± 1.5 bc	9 ± 3.3 b
4% Formaldehyde	10 ± 2.4 a	8 ± 2.2 bc	11 ± 3.9 b
10% Formaldehyde	10 ± 2.5 a	14 ± 5.4 a	17 ± 3.7 a
100 ppm Streptomycin	9 ± 3.2 a	10 ± 2.8 bc	10 ± 3.2 b
200 ppm Streptomycin	8 ± 1.3 a	12 ± 2.8 ab	10 ± 2.7 b

[y]No treatment = pierced, no chemical treatment dip, 10 min deionized water dip.
[z]Mean separation within columns by Duncan's multiple range test, $P = 0.05$.
[x]Control = no pierce, no inoculation, no chemical treatment or deionized water dip.

trol. Piercing the rhizomes did not increase the bacterial incidence as indicated by the low percentage of infected control rhizomes that were not pierced or treated verses those rhizomes that were pierced, not inoculated, and not chemically treated. Most rhizomes inoculated with *Ecc* took longer to emerge, as was indicated in Expt. 2 (Table 5). Days to emergence was not significantly affected by most chemical treatments.

The susceptibility of the rhizomes to *Ecc* was not as clearly defined as in Expt. 1. After observing infection rates of plants in other *Zantedeschia* experiments, it appears that the condition of the rhizome before planting (i.e., vigor of rhizome, field infection, preinfection, and desiccation) greatly contributes to the incidence of *Ecc* infection. This can vary between species, storage conditions, time of shipment, and time of planting after shipment. Determining which rhizomes are infected before planting is also difficult or impossible; therefore, it is imperative that rhizomes are treated to reduce the incidence of *Ecc* infection.

Although *Ecc* cannot be completely controlled by chemical treatment of the rhizomes, a 200 ppm streptomycin dip for 30 min can significantly reduce *Ecc* infection. Formaldehyde provided the second best control. Chemical treatments did not significantly reduce the days to emergence of most rhizomes or decrease the final size of the plant (data not shown). Before these chemical treatments are used; however, local guidelines for disposal of the chemical should be consulted. Further studies that investigate field infected *Zantadeschia* rhizomes and the use of other chemical treatments such as copper compounds need to be conducted.

Literature cited

Corr, B.E. 1990. Calla lilies as flowering potted plants. Tenn. Flower Grow. Nwsl. 4(4):2–3.

Corr, B.E. 1993. *Zantedeschia* research in the United States: Past, present and future. Acta Hort. 337:177–187.

Tjia, B. 1985. Hybrid calla lilies: A potential new crop for Florida. Proc. Fla. State Hort. Soc. 98:127–130.

Tjia, B. and U. Jierwiriyipant 1988. Preplant treatments of calla lily tubers to control *Erwinia*. Fla. Orn. Growers Assn. Nwsl. 11(3):6–7.

Interplanted Small Grain Cover Crops in Pickling Cucumbers

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ADDITIONAL INDEX WORDS. living mulch, vegetable, companion crop

SUMMARY. Pickling cucumbers (*Cucumis sativus* L.) for machine harvest were interplanted with barley (*Hordeum vulgare* L.), oat (*Avena sativa* L.), rye (*Secale cereale* L.), sorghum-sudan (*Sorghum vulgare* L.), or wheat (*Triticum aestivum* L.). Cover crops 3 to 5 (7.6 to 12.7 cm) or 6 to 10 inches (15.2 to 25.4 cm) tall were killed with sethoxydim. Cover crops seeded at ≈12 seeds/ft² (129 seeds/m²) provided protection from wind erosion and minimal crop competition. Additional nitrogen to obtain maximum yield was required when small grain cover crops were interplanted with cucumbers. Barley emerged rapidly, grew upright, and was killed easily with sethoxydim, making it ideal for interplanting. All cover crops caused some cucumber yield reduction under adverse growing conditions.

Pickling cucumbers are frequently grown on sandy soils subject to wind and water erosion. Between emergence and the two-leaf stage, cucumber seedlings are especially susceptible to injury from wind-blown sand.

Windbreaks of various types have been used in many crops to protect

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