Effects of Growth Regulator Chlormequat Chloride on Severity of Three Bacterial Diseases on 10 Cultivars of *Hibiscus rosa-sinensis*

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ABSTRACT

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The effects of the growth regulator chlormequat chloride on severity of bacterial diseases caused by *Pseudomonas cichorii, P. syringae* pv. *hibisci,* and *Xanthomonas campestris* pv. *malvacearum* was evaluated on 10 cultivars of *Hibiscus rosa-sinensis*. Plants treated with chlormequat chloride had fewer leaves (mean of two to four per plant) and were 3.8–12.7 cm shorter than untreated plants. The mean severity of disease caused by *P. cichorii* on 10 cultivars was reduced an average of 33.9% in three tests for plants treated with chlormequat chloride. The mean severity of disease caused by *P. syringae* pv. *hibisci* on these cultivars was reduced by 68.5% for three tests when plants were treated with chlormequat chloride. The mean severity of disease caused by *X. campestris* pv. *malvacearum* on nine cultivars was reduced an average of 47.9% for three tests when plants were treated with chlormequat chloride. There were no differences in susceptibility of the cultivars to *P. cichorii*. However, plants were differentially susceptible to *P. syringae* pv. *hibisci*; cultivars White Red Eye and President were very resistant, and Brilliant Red, Painted Lady, and Holiday were very susceptible. Cultivars Senorita and American Beauty were most susceptible to *X. campestris* pv. *malvacearum*, and Euterpe was very resistant.

Growth regulators are used on a wide variety of ornamental crops to improve rooting, increase shoot formation, shorten internodes, and induce flowering (1–3). The effects of some of these compounds on pests have been investigated on many crops. Ethephon and BA (6-benzylamino purine) increased severity of Ascochyta ray blight on chrysanthemum (9). Wilt diseases such as Verticillium on tomato (11) or cotton (6) have been reduced when plants were treated with the growth regulator chlormequat chloride (Cycocel). Southern blight (caused by *Sclerotium rolfsii* Sacc.) was reduced in bean seedlings treated with chlormequat chloride, whereas the same treatment increased number of local lesions caused by tobacco mosaic virus (TMV) on *Nicotiana glutinosa* L. (12). In apparent contrast, TMV multiplication was lower in chlormequat chloride-treated plants than in untreated plants (8). In other studies, chlormequat chloride applications were superior to bactericides for control of *Xanthomonas campestris* (*X. c.*) pv. *vesicatoria* (Doidge) Dye on pepper (5). Grower observations regarding two-spotted spider mite populations on *Hibiscus rosa-sinensis* L. led to a study involving *Tetranychus urticae* Koch and chlormequat chloride, which is commonly used on this crop (2,3). Hibiscus are also hosts of three bacterial pathogens found in Florida (4). Because obvious alterations in leaf appearance occur after chlormequat chloride treatment, the potential for differential susceptibility of hibiscus cultivars to foliar diseases exists. Effects of chlormequat chloride treatment on severity of bacterial leaf spot diseases caused by *Pseudomonas cichorii* (Swing.) Stapp, *P. syringae* pv. *hibisci* (*P. s.* pv. *hibisci*) Jones et al (7), and *X. c.* pv. *malvacearum* (E. F. Sm.) Dows. on 10 cultivars of hibiscus were evaluated.

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MATERIALS AND METHODS

Rooted cuttings of the cultivars listed in Table 1 were obtained from Yoder Brothers of Florida, Inc., for each test. Cuttings were established in a potting medium consisting of steam-treated (90 C for 1.5 hr), Canadian peat and pine bark (1:1, v/v). The medium was amended with 4.4 kg of Osmocote 19:6:12 (slow-release fertilizer from Sierra Chemical Co., Milpitas, CA), 4.2 kg of dolomite, and 0.9 kg of Micromax (micronutrient source also from Sierra) per cubic meter. Plants were grown in 10-cm-diameter plastic pots in a glasshouse at 18–33 C and a maximum light level of 200 $\mu mol \cdot s^{-1} \cdot m^{-2}$. Ten plants of each cultivar were treated with water only or chlormequat chloride three times at weekly intervals starting no sooner than 3 wk after potting. Chlormequat chloride was used at the rate of 7.8 ml/L and applied to runoff only. Number of leaves and plant height were recorded before the first chlormequat chloride treatment and again 1 wk after the final treatment. Plants were misted for 24 hr before inoculation (5 sec/30 min from 0800 to 2000 hours daily), continuing until ratings were completed.

Inocula for each test were prepared from a single strain each of *P. cichorii, P. s.* pv. *hibisci,* or *X. c.* pv. *malvacearum* originally obtained from *H. rosa-sinensis* (4). Cultures (48 hr old on nutrient agar) were diluted in sterilized deionized water (SDW) and adjusted to about 1×10^8 colony-forming units per milliliter with a spectrophotometer (50% transmittance at 600 nm). The bacterial suspension was applied to runoff with a pump-action hand sprayer, and plants were placed in polyethylene bags for 48–72 hr after inoculation. Disease severity was rated from 4 to 14 days after inoculation depending on the pathogen involved. Mean numbers of lesions per leaf were recorded for *P. cichorii* and *P. s.* pv. *hibisci* and the percentage of leaf area symptomatic was recorded for *X. c.* pv. *malvacearum* tests. The experiment was performed three times for each of the three bacterial pathogens.

Data were analyzed directly, except percentage data were transformed using the arc sine of the square root of the percentage before analysis. Dates from the three tests on a given pathogen were combined for final analysis, and Duncan's new multiple range test was employed to separate means.

RESULTS

Interactions between chlormequat chloride treatment and cultivar were not significant, and only main effects are presented. Height and number of leaves were reduced for all 10 cultivars treated with chlormequat chloride. Heights were reduced from as little as 3.8 to as much as 12.7 cm, depending on the cultivar. Leaf numbers were not always significantly affected by chlormequat chloride treatment, although in most of the tests, chlormequat chloride-treated plants had two to four fewer leaves than water-treated plants, an average reduction of 9.7%.

Disease severity caused by *P. cichorii*, as indicated by mean number of lesions per leaf, was reduced an average of 33.9% (Table 1). Differences in susceptibility of these cultivars to *P. cichorii* were not significant (Table 1).

Severity of disease caused by *P. s.* pv. *hibisci* was reduced an average of 68.5% in plants treated with chlormequat chloride (Table 1). Cultivars showed different degrees of susceptibility to this pathogen. White Red Eye and President were highly resistant to *P. s.* pv. *hibisci*, and American Beauty, Pink Versicolor, Butterfly, and Euterpe were moderately resistant. Brilliant Red, Holiday, and Painted Lady were the most susceptible to *P. s.* pv. *hibisci* of the cultivars tested (Table 1). Other cultivars showed intermediate susceptibility to *P. syringae* pv. *hibisci* in these tests.

The percentage of plants infected with Xanthomonas leaf spot was reduced an average of 47.9 when plants were treated with chlormequat chloride (Table 1). Differences in cultivar resistance to *X. c.* pv. *malvacearum* showed that Euterpe was most resistant to *X. c.* pv. *malvacearum*, with no disease detected in two of three tests. Brilliant Red, President, and Painted Lady were also moderately resistant to this pathogen, whereas Senorita and American Beauty were highly susceptible (Table 1).

Table 1. Effects of chlormequat chloride and cultivar on severity of bacterial leaf spot of *Hibiscus rosa-sinensis* caused by *Pseudomonas cichorii, P. syringae* pv. *hibisci*, or *Xanthomonas campestris* pv. *malvacearum*

	Mean no. lesions/leaf		Mean percent leaf area infected
	P. cichorii	***P. syringae* pv. *hibisci***	***X. campestris* pv. *malvacearum***
Chlormequat chloride treatment[x]			
+	1.10 a[y]	0.96 a	14.33 a
−	1.66 b	3.03 b	27.52 b
Cultivar			
Euterpe	1.06 a	1.42 ab	4.33 a
White Red Eye	0.98 a	0.56 a	19.50 ab
Senorita	1.42 a	2.47 abc	42.67 d
President	1.64 a	0.56 a	10.17 ab
Brilliant Red	1.70 a	3.33 bc	8.83 ab
Pink Versicolor	1.64 a	1.28 ab	27.33 bcd
American beauty	1.23 a	1.15 ab	39.33 cd
Butterfly	1.46 a	1.33 ab	23.33 bc
Holiday	1.58 a	4.47 c	...[z]
Painted Lady	1.06 a	3.37 bc	12.83 ab

[x] Plants were treated three times at weekly intervals with 7.8 ml/L to runoff.
[y] Mean separation within columns according to Duncan's multiple range test ($P = 0.05$).
[z] Not available for testing.

DISCUSSION

The responses of these 10 cultivars to three bacterial pathogens of hibiscus were variable, depending on the pathogen well as the cultivars included. Comparing the reactions of some of the cultivars used in this study with Phytophthora leaf spot shows that American Beauty is very resistant to *P. parasitica*, whereas Brilliant Red is very susceptible to this pathogen (10). Choice of hibiscus cultivar on the basis of susceptibility to these foliar diseases would be difficult because they are all moderately susceptible to *P. cichorii* and at least one of the other three pathogens. The degree of host specificity of the individual pathogens may explain why all cultivars tested showed a similar degree of susceptibility to *P. cichorii. P. cichorii* has a wide host range including vegetables and woody and herbaceous ornamentals, and no reports of resistance to *P. cichorii* have been made. In contrast, both *P. s.* pv. *hibisci* and *X. c.* pv. *malvacearum* have narrower host ranges, affecting a single genus or family. It is possible that this specialization to a host group is reflected in the development of host resistance to the pathogen.

Chlormequat chloride treatment of hibiscus is a widespread practice among plant producers (2,3). In our tests, chlormequat chloride significantly reduced disease severity for three bacterial pathogens as well as growth of these hibiscus cultivars. Although differences in plant growth are obvious, reductions in numbers of leaves (about 9.7%), and thus possible infection courts, cannot explain decreases from 33.9 to 68.5% in disease severity that were found in our tests. Therefore, the cause of increased resistance for chlormequat chloride-treated hibiscus may be physical or biochemical and remains to be determined.

The practical use of chlormequat chloride as a disease control agent on hibiscus cultivars may be important, because few commercial, highly effective bactericides are available. The dwarfing effect of chlormequat chloride on hibiscus cultivars has been found to persist for at least 360 days (2), indicating the potential for lasting reductions in susceptibility to these bacterial diseases as well.

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