A Fungus Among Us...

A NEW LOOK at FUNGICIDES FOR MANAGING GERANIUM RUST

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In the spring of 1997, an epidemic of rust on zonal geraniums (*Pelargonium* x *hortorum*) occurred in plant beds on the coast of South Carolina (3). This was one of the most serious epidemics of geranium rust that has occurred in the United States in recent years. In addition, diseased geraniums were found at nurseries and greenhouses and were distributed to retail outlets in South Carolina and other parts of the Southeast. This situation occurred despite applications of fungicides for rust control (primarily triadimefon, e.g., Strike and related products). Geranium rust, which is caused by the fungus *Puccinia pelargonii-zonalis*, is not endemic to the United States and occurs only sporadically and usually insignificantly each year when the pathogen inadvertently is brought into the United States on infected or contaminated geranium cuttings or plants coming from locations where the disease is endemic (1,2). Some people in the industry consider rust to be one of the most potentially threatening diseases to the production and cultivation of zonal geraniums in the United States because there are not adequate methods for detecting the pathogen on symptomless but contaminated or infected propagation stock coming into this country from foreign locations. Research on the efficacy of fungicides for controlling geranium rust has been very limited (2,4,5). Consequently, a project was initiated to evaluate the effectiveness of currently available fungicides for managing rust on zonal geraniums. This is an interim report because our research still is in progress.

Fungicides were evaluated on geranium plants (cv. Veronica) that were grown from rooted cuttings in a greenhouse for approximately two months. Plants were moved into a growth chamber at 17-21°C with a 14-hour photoperiod for inoculation and symptom development after treatments were applied because geranium rust does not develop well at temperatures above 25°C (2). In all, seven fungicides were evaluated (see Table 1) at rates recommended on product labels or by the manufacturer. Strike, Systhane, Daconil, and Dithane are registered for control of geranium rust in the United States, but Strike is used most frequently. Baycor is registered for geranium rust control outside the United States—where it is becoming a popular product for rust control. Rubigan and Phyton are registered for use on ornamental crops in the United States but are not registered specifically for geranium rust. Strike, Systhane, Baycor and Rubigan are newer chemistry, demethylation-inhibiting (DMI) fungicides—which provide protective as well as some eradicative activity because they are taken up by the plants. Daconil, Dithane, and Phyton are traditional broad-spectrum, protectant fungicides that are active only on plant surfaces. Phyton was evaluated at two rates because of the broad range of rates recommended on the product label. Combinations of Strike or Systhane mixed with Daconil or Dithane were evaluated to take advantage of two different types of fungicide chemistry in a single treatment; full rates of both ingredients were used in all mixtures. Treatments were prepared with tap water in 500-ml volumes (see Table 1) and were applied with a CO_2-powered sprayer equipped with a single-nozzle spray boom. Treatments were applied twice with applications one week apart.

Plants were inoculated approximately 24 hours after treatments were applied. The pathogen, *P. pelargonii-zonalis,* was collected on infected plants in the summer of 1997 and has been maintained on geranium plants in a growth chamber. A suspension of spores was prepared in water plus a surfactant, and this inoculum was applied to the plants with a hand-pump spray bottle. Inoculated plants were maintained at 100% relative humidity for 24 hours to

Table 1. Fungicides and application rates used to control rust on zonal geraniums.

Trade Name	Formulation	Common Name	Recommended Rate[x]	Application Rate[y]
Strike	25 WP	triadimefon	2.0 oz/50 gal	150 mg
Systhane	40 WP	myclobutanil	2.0 oz/50 gal	150 mg
Rubigan	1 EC	fenarimol	5.0 fl oz/100 gal	0.2 ml
Baycor	300 EC (metric)	bitertanol	38.0 fl oz/100 gal	1.5 ml
Daconil Ultrex	82.5 WDG	chlorothalonil	1.4 lb/100 gal	840 mg
Dithane T/O	75 WDG	mancozeb	1.5 lb/100 gal	900 mg
Phyton 27[z]	21.36 S	copper sulfate	2.5 fl oz/10 gal	1.0 ml
		pentahydrate	5.0 fl oz/10 gal	2.0 ml

[x] The amount of formulated product added to a designated volume of water recommended on the product label or by the manufacturer.
[y] The amount of formulated product added to 500 ml of water and applied to geranium plants.
[z] Phyton 27 was evaluated at two rates: 1x and 2x.

be sure infection occurred (2). Plants were evaluated five weeks later by counting the number of lesions per leaf and then calculating the total number of lesions and the number of diseased leaves on each plant. We also measured diameters of individual lesions. Data were analyzed by one-way analysis of variance (ANOVA), and means were separated by Fisher's Protected Least Significant Difference (LSD; P=0.05). The experiment was repeated, and similar experiments with different complements of treatments have been conducted.

When treatments were applied ***before*** inoculation under controlled conditions, all fungicides significantly reduced the incidence of geranium rust compared to the untreated control (see Table 2). Although the number of lesions per plant ranged from zero to 9.4 for the twelve fungicide treatments, there was no significant difference among these treatments—which was due primarily to the high variability associated with the Control treatment. However, when the twelve fungicide treatments were analyzed without the Control treatment included, significant differences among the fungicides were identified. Similar differences among treatments were observed when the numbers of diseased leaves per plant were analyzed. Baycor, Daconil, Dithane, and the four combination treatments—all of which contained either Daconil or Dithane—protected plants completely; disease management with Systhane also was very good and was not significantly different from these treatments. Rubigan and the high rate of Phyton were somewhat less effective whereas Strike and the low rate of Phyton were not as effective as any of the best products. On plants where lesions developed, lesions were smallest after treatment with Systhane whereas treatment with Phyton, at either rate, had no effect on lesion size compared to the untreated control. Similar results were observed when this experiment was repeated and in other experiments. Phytotoxicity was observed with the high rate of Phyton; some leaves developed marginal necrosis 24 hours after application. In addition, some plants treated with Dithane developed a mild chlorosis or mottled appearance, and treatment with this product usually left a noticeable residue.

These results suggest that geranium rust on can be managed effectively with timely applications of broad-spectrum protectant fungicides containing chlorothalonil (which is found in Daconil Ultrex and related products) or mancozeb (which is found in Dithane T/O and related products). The protectant fungicide Phyton, which is registered for several other geranium diseases, should provide some protection from rust but should not be relied on exclusively. Of the newer chemistry DMI fungicides evaluated, Baycor provided excellent control but is not registered in the United States; it should be considered for rust management programs in geranium production operations outside the United States. Of the DMI products available in the United States—Systhane, which is registered for geranium rust, provided very good control and Rubigan, which is not registered for this disease, looked promising.

In theory, the best management strategy should be to use a mixture of a protectant fungicide and a DMI fungicide because applications can not always be made before inoculum is present. However, we were unable to prove this theory in these experiments because the protectants alone provided complete protection. It is important to note that efficacies of these products in a production greenhouse or under field conditions may be different than those

Table 2. Efficacy of fungicides against geranium rust when applied before inoculation.

Treatment	No. Lesions per Plant[w,x]		No. Diseased Leaves per Plant[w]	Lesion Diameter (mm)[w]
Strike	9.4 a	C	2.4 c	2.5 c
Systhane	0.8 a	A	0.8 ab	1.3 b
Rubigan	4.6 a	B	1.0 ab	2.5 c
Baycor	0.0 a	A	0.0 a	0.0 a
Daconil	0.0 a	A	0.0 a	0.0 a
Dithane	0.0 a	A	0.0 a	0.0 a
Phyton/1x	9.0 a	C	2.8 c	5.4 d
Phyton/2x	2.8 a	AB	1.8 bc	5.2 d
Strike + Daconil	0.0 a	A	0.0 a	0.0 a
Strike + Dithane	0.0 a	A	0.0 a	0.0 a
Systhane + Daconil	0.0 a	A	0.0 a	0.0 a
Systhane + Dithane	0.0 a	A	0.0 a	0.0 a
Control	76.2 b	—	6.8 d	5.2 d
P value[y]	<0.001	<0.001	<0.001	<0.001
LSD[z]	17.80	3.77	1.10	0.80

[w] Values are means of five replicates; means followed by the same letter are not significantly different.
[x] These data were analyzed and treatment means were compared with (lower case letters) and without (upper case letters) the Control treatment (see text).
[y] *P* values for *F* statistics from one-way analyses of variance (ANOVAs).
[z] Fisher's Least Significant Difference (LSD) with $P=0.05$ for separating means within a column.

reported here because in these situations inoculum probably will be present much of the time and infection periods can occur daily. In conclusion, geranium growers should be able to manage rust on zonal geraniums with the products currently available; however, they should **not** rely solely on one product—which frequently has been done in the past

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