Hot-Water Therapy for Geranium Rust Control

Douglas J. Phillips and Arthur H. McCain

Plant Pathologist, ARS, USDA, 2021 South Peach Avenue, Fresno, California 93727; and Extension Plant Pathologist, Department of Plant Pathology, University of California, Berkeley 94720, respectively.

We thank the Nursery Service, Division of Plant Industry, California Department of Agriculture, the Agricultural Commissioner offices of San Diego and Fresno Counties, and James R. Breece, San Diego County Farm Advisor, for assistance in facilitating our work.

Accepted for publication 30 August 1972.

ABSTRACT

Rust incited by *Puccinia pelargonii-zonalis* did not develop on infected geranium cuttings, *Pelargonium hortorum* (× *P. zonale*), after they were dipped for 90 sec in water at 50 or 52 C, or were held 24 or 48 hr in water-saturated air at 38 C. The hot-water treatment permitted germination of some urediospores, particularly those taken from poorly growing plants. Hot water damaged small expanding leaves, but did not retard subsequent plant growth.

Phytopathology 63:273-275

Additional key word: thermotherapy.

In August 1967, rust caused by *Puccinia pelargonii-zonalis* Doidge was first reported in California on the horseshoe geranium, *Pelargonium hortorum* Bailey (X *P. zonale* Willd.) (5). Growers have tried to keep field-grown stock plants free from this disease, but its rapid spread shows the need for effective control measures (3, 6, 7, 9, 10, 13). Chemical sprays offer a degree of protection, but eradication is difficult (4, 10). Postharvest, hot-air thermotherapy of geranium cuttings offers a high or eradicative level of control (11); however, the long treatment time, 48 hr at 38 C, is not practical for field operations in California. Because the rusts, *Uromyces phaseolus* and *Puccinia methae*, have been controlled effectively by treatment with hot water (12, 15), we tested the effectiveness of this method for control of geranium rust.

MATERIALS AND METHODS.—*Heat-treated cuttings grown in a greenhouse.*—Unrooted geranium stem cuttings, *P. hortorum* (X *P. zonale*) from growers in California, were either naturally infected or inoculated with *P. pelargonii-zonalis*, using Grouet's technique (11). Viable urediospores for inoculation were collected in Monterey County, Calif. In four tests, infected cuttings (600/test) were treated with water-saturated air at 38 C for 24 or 48 hr, or with water at 46, 50, or 52 C for 90 sec. In the first two tests with hot water, an emulsified wax was added to water at 52 C. The wax, which was of little value, was not used in two subsequent tests, and water temperature was reduced to 50 C, which seemed less hazardous.

Hot-air treatments were conducted in a forced-air controlled temperature and humidity chamber (Blue M electric model CF-7502-HA). Plants for the hot-water treatments were packed loosely in wire baskets (50/lot) and immersed in an insulated, stainless-steel tank containing about 300 liters of hot water. Water was circulated constantly during the treatments, and temperatures were maintained by a controller equipped with a thermistor probe. The treated plants were allowed to cool in air for 10 min, then packed into shipping boxes.

After treatment and 1 day in transit, cuttings were planted in pots arranged in a randomized block design in a greenhouse at the University of California, Berkeley; the greenhouse temperature was regulated at 25 ± 5 C and the plants were watered twice daily After 3 to 5 weeks, the incidence of rust and heat-related damage was recorded.

Six varieties were treated in two tests and a single variety was used in two other tests.

Urediospore germination tests.—Leaves with active urediosori, collected in the summer of 1971 in Monterey County, Calif., were treated in water at 50 C for 60 or 90 sec. Urediospores were taken from sori of heat-treated or untreated leaves, placed in a drop of water on a water agar plate, and incubated at 20-21 C. Germinating spores were counted after 48 hr.

RESULTS.—No rust developed on plants from cuttings treated for 24 or 48 hr in 38 C air or for 90 sec in 50 or 51 C water. Pustules on naturally infected cuttings were inactivated by the treatments. Although warm weather (greenhouse temperatures reached 31 C) limited disease development, rust developed in check lots of three of the four tests.

For the third test (Table 1), naturally infected cuttings were used, and rust (seven replications) and injury (four replications) were evaluated on cuttings in the greenhouse. No rust was found in any sample treated at 50 C. Treatment in 46-C water, however, did not control rust, and increased the incidence of stem rot caused by *Pythium* sp. (data not shown).

Hot-air treatment caused little or no damage (Table 1). From 0 to 60% of the plants treated with hot water exhibited heat damage. Injury was usually confined to the petiole and main veins of expanding leaves. Although injured leaves often abscised, hot water-treated cuttings generally grew normally. Water at 52 C seemed more injurious than at 50 C. Little or no difference in varietal response to heat was observed.

Urediospore germination tests.—Urediospores failed to germinate after 30 sec in 51-C water in vitro. In three later tests, sori from whole leaves or cuttings taken from inoculated plants grown in greenhouse tests yielded no viable urediospores after a water treatment at 50 C (Fig. 1). The fourth test included leaves from plants grown outdoors in a window box, and some urediospores germinated after treatment. Subsequent hot-water treatment of infected leaves from various locations indicated that mean urediospore germination could be expected to range from 2.7 to 0% after a 90-sec dip in 50 C water (Table 2). Age of the pustules apparently was not related to this variation. Vigorous plants, however, seemed to yield fewer viable spores after hot-water treatment than did poorly growing plants.

DISCUSSION.–Under greenhouse conditions that allow moderate rust development, our tests confirmed those of Grouet (11), but also showed effective control with a 24-hr hot-air treatment. A 90-sec, 50 to 51-C hot-water treatment provided effective therapy, but may have left some spores capable of germination on treated plants. Spore germination on a water agar plate test, however, may not indicate true viability (8), and may be too high an estimate of the spores' ability to cause infection. Nevertheless, this inoculum could assume significance, especially if the treatment predisposes the host to infection (14, 16). Therefore, a hot-water dip for cuttings should be used in conjunction with a rust control program that reduces as much as possible inoculum density on the mother plant.

Generally, hot water caused more damage to "soft" than to "hard" cuttings, and may be more applicable to field-grown cuttings than to greenhouse-grown stock. Heat tolerance can be induced in other plants (2), and injury to the geraniums from the hot-water treatment might be minimized.

TABLE 1. The incidence of *Puccinia pelargonii-zonalis* Doidge, and heat-related leaf injury, on stem cuttings of geranium, *Pelargonium hortorum* Bailey (× *P. zonale* Willd.) 'Sincerity', 33 days after treatment with hot air or hot water[a]

	Hot air[b]		Hot water[c]		
	24 hr	48 hr	46 C	50 C	Control
% Plants with rust	0	0	12	0	12
	0	0	24	0	6
	0	0	6	0	12
	0	0	12	0	6
	0	0	18	0	12
	0	0	0	0	24
	0	0	0	0	18
Mean	0	0	10	0	13
% Plants with heat-related leaf injury	0	0	20	20	0
	0	0	0	10	0
	0	0	30	10	0
	0	0	0	60	0
Mean	0	0	12	25	0

[a] After the treatments, the cuttings were planted in a greenhouse. Each datum represents a sample of 17 plants.
[b] Water-saturated air at 38 C in forced-air chamber.
[c] 90-sec dip in constantly agitated water.

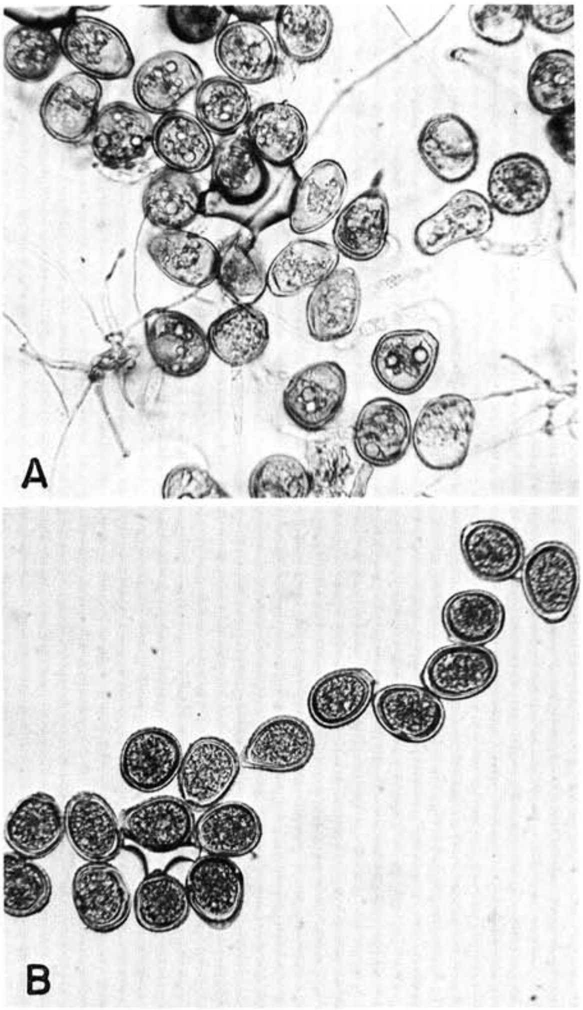

Fig. 1. Urediospores on water agar 48 hr after removal from: **A)** untreated infected plants; **B)** plants dipped 90 sec into 50 C water. Note that the untreated sample (A) includes hyphae of other fungi in addition to the rust germlings.

In addition to heat tolerance in the host, heat sensitivity might be induced in the pathogen. Yarwood showed that longer treatments are needed to control bean rust late in the day than early in the morning (15). Our results suggest that hot-water therapy controls rust better on vigorously growing plants than on poorly growing ones. Possibly the moisture content of plant tissues, known to be of great importance in thermotherapy (1), changes the hydration of the rust spore. Further research may show that watering schedules or other cultural practices could be adjusted to decrease the thermal death point of the parasite while protecting the host from thermal damage.

While effective heat treatment for rust may control other pathogens such as *Botrytis* sp., still other pathogens may be disseminated. Bacterial stem rot, incited by *Xanthomonas pelargonii* (Brown) Starr

TABLE 2. Germination (%) of urediospores of *Puccinia pelargonii-zonalis* after hot-water treatment[a]

Collection	California location	Plant growing conditions	No. spores sampled/ treatment	% Germination of spores after treatment in 50 C water for indicated time (sec)		
				0	60	90
24 May 1971	Berkeley	Poor	600	77.2	18.7	1.7
11 June 1971	Watsonville	Good	20,000	53.9	0.1	0.0
25 June 1971	Monterey	Good	600	81.7		0.8
20 Oct. 1971	Pacific Grove	Good	2,000	52.0	0.0	0.0
20 Oct. 1971	Carmel Valley	Poor	1,700	61.7	2.4	1.3
20 Oct. 1971	Carmel Valley	Fair	1,900	93.7	2.9	0.7
Mean of all collections				70.0	4.8	0.7
99.9% confidence interval				100-23	35-0	2.7-0

[a] In each test, spores were taken from leaf pustules, after treatment for 0, 60, or 90 sec in 50-C water, and placed in a water drop on water agar. Germination of 100 spores/pustle was recorded.

& Burk., has not been seen in the hot water-treated plants; however, preliminary tests indicate that a bactericide is needed in the hot water to assure that the bacterium is not disseminated during the treatment.

Further studies are underway to determine the effects of hot-water dips and chlorination on geranium cuttings during handling and shipping.

LITERATURE CITED

1. BAKER, K. F. 1962. Principles of heat treatment of soil and planting material. J. Australian Inst. Agr. Sci. 28:118-126.
2. BAKER, K. F. 1962. Thermotherapy of plant material. Phytopathology 52:1244-1255.
3. BARTOLONI, P., & A. BONIFACIA. 1967. La ruggins del geranio in Toscana. Rivista Ortoflorofrutticolt. Ital. 51:146-148.
4. BIVINS, J. L., & A. H. MC CAIN. 1971. Control of geranium rust with oxycarboxin. Calif. Plant Pathol. 1:1-3.
5. CALIFORNIA DEPARTMENT OF AGRICULTURE. 1967. Report of new or unusual plant pathogen P1 Path -A-67-8. Looseleaf. n.p.
6. DOIDGE, E. M. 1926. A preliminary study of the South African rust fungi. Bothalia 2:98-99.
7. EVANS, S. G. 1966. New or uncommon plant diseases and pests. Plant Pathol. 15:119, 144.
8. FARRELL, J., & A. H. ROSE. 1967. Temperature effects on microorganisms, p. 147-218. *In* A. H. Rose [ed.]. Thermobiology. Academic Press, New York.
9. GERLACH, W. 1965. Eine neue Pilzkrankheit breitet sich in Europa aus: der Pelargonienrost (Puccinia perlargonii-zonalis Doid.). Nachrichtenbl. Deutsch. Pflanzenschutz. Dienst. 17:97-100.
10. GIBBS, J. G. 1936. Pelargonium-rust. New Zealand J. Agr. 52:142-147.
11. GROUET, D. 1965. La rouille du Pelargonium zonale. Traitement par thermotherapie. Epiphyties 16:315-331.
12. OGILVIE, L., & C. J. HICKMAN. 1937. Progress report on vegetable diseases. VIII. Annu. Rep. Agr. Hort. Res. Sta. Long Ashton Bristol 1936. p. 139-148.
13. WEHLBURG, C. 1970. Pelargonium rust (Puccinia pelargonii-zonalis) in Florida. Plant Dis. Reptr. 54:827-828.
14. YARWOOD, C. E. 1956. Heat induced susceptibility of beans to some viruses and fungi. Phytopathology 46:523-525.
15. YARWOOD, C. E. 1963. Heat therapy of bean rust. Phytopathology 53:1313-1316.
16. YARWOOD, C. E. 1966. Similarity of predisposition and therapy. Phytopathology 56:140.