Translocated Heat Therapy of Bean Rust

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Accepted for publication 1 March 1978.

ABSTRACT

YARWOOD, C. E. 1978. Translocated heat therapy of bean rust. Phytopathology 68: 1170-1171.

When the distal halves of bean leaves were heated for 10 sec in water at 75 C 10 hr after inoculation with *Uromyces phaseoli*, the heated tissue was killed, and most of the *U. phaseoli* in the proximal halves of the same leaves was killed without permanent injury to the proximal leaf tissue. The amount of surviving fungus in the nonheated tissue was further reduced if the entire leaf was dipped in water at 45 C or in ice water for 10 sec immediately after heat treatment.

Additional key words: *Uromyces phaseoli*.

Direct heat therapy is an effective but still limited method of disease control which is readily studied quantitatively with bean rust (3). Translocated heat therapy (4) has been mentioned briefly as an application of translocated heat injury (2) but no quantitative information was given. Cold therapy (5) has been found to apply to several rusts and one downy mildew. This is a study of the combined effects of translocated heat injury, cold therapy, and direct heat therapy.

MATERIALS AND METHODS

The distal halves of primary leaves of rusted beans (uredinial stage of *Uromyces phaseoli* in *Phaseolus vulgaris* 'Pinto') usually were heated in water the day after inoculation. Cowpea rust, bean powdery mildew, and cucumber powdery mildew were tested to a limited extent. The maximum distance of the nonheated tissue from the heated tissue was about 5 cm. The cause of reduced infection in the proximal nonheated portions of these leaves, in comparison with the infection in comparable unheated leaves is considered to be translocated heat therapy. Dosage of heat was regulated by the temperature of the waterbath (45-90 C) and the duration of immersion (0.5 to 60 sec). Results usually were recorded as the minimum number of pustules per square centimeter closest to the heated tissue, and the maximum number of pustules most distant from the heated tissue.

RESULTS

Average results of the six most recent trials are given in Table 1. Translocated heat therapy (THT), like translocated heat injury (THI), was observed only if the heated tissue was killed. For standard treatments of 10 sec duration, there was a gradient of increasing THT from 55 (no THT) to 75 C, with no (or very little) additional THT at higher temperatures. At 65 C there was a gradient of increasing THT with increasing heat dosages of 3, 6, 12, 24, and 48 sec but with little or no increased THT with dosages greater than 48 sec. Usually there was a gradient from complete therapy immediately adjacent to the heated tissue to no (or much less) therapy in tissue most distant from the heated tissue (Fig. 1). Complete therapy of rust in all inoculated tissue proximal to the heated tissue was attained in only 3 of 58 trials, but nothing otherwise distinctive of those trials was noted.

The earliest infections tested were 8.5 hr after inoculation (Fig. 1), with complete inhibition of rust up to 20 mm from the heated tissue. The oldest infections tested were 109 hr after inoculation, with inhibition up to 12 mm. Average distances of therapy decreased with the age of infection.

At all effective heat dosages tested THT increased if the previously unheated tissue of the heated leaf was immersed in ice water immediately after the heat treatment (Fig. 1). The *U. phaseoli* that survived the THT treatment was killed at a lower dosage of heat than that in tissue not subjected to the THT treatment. This, and the above finding that cold treatment increases THT, supports the idea that THT is a manifestation of THI.

Limited tests with cowpea rust (*Uromyces phaseoli* on

TABLE 1. Translocated heat therapy of bean rust

Treatment of leaves	Average lesions in proximal part of leaf	
	Minimum (no./cm^2)	Maximum (no./cm^2)
None	30	44
10 sec at 55 C to distal half	28	44
10 sec at 75 C to distal half	8.3	21
10 sec at 75 C to distal, then 10 sec at 0 C to entire	4.8	18
10 sec at 75 C to distal, then 10 sec at 45 C to entire	0.4	12
10 sec at 0 C to entire	28	39
10 sec at 0 C to entire, then 10 sec at 75 C to distal	7.0	20
10 sec at 45 C to entire	10	32
10 sec at 45 C to entire, then 10 sec at 75 C to distal	0.1	6.0

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Fig. 1. Translocated heat therapy of bean rust. All leaves were inoculated on 28 June, and photographed 18 July. The distal half of the upper leaf was heated 10 sec at 55 C on 29 June. The rust pathogen (*Uromyces phaseoli*) in the heated portion was killed without heat injury to the leaf but in the proximal portion of the leaf it was not affected. The distal half of the middle leaf was heated 10 sec at 70 C on 29 June. The leaf tissue and the rust pathogen were both killed in the heated tissue and the rust in the nonheated proximal tissue was killed in a gradient from complete therapy in the tissue immediately adjacent to the heated tissue to practically no therapy in the tissue most distant from the heated tissue. The distal half of the lower leaf was heated 10 sec at 70 C, and the entire leaf then immediately dipped in ice water for 5 sec. The cold treatment has greatly increased the translocated therapy caused by the heat treatment; this cold treatment alone, in other tests, had no apparent effect on infection.

Vigna sinensis 'Blackeye') gave results similar to those with bean rust. With bean powdery mildew (*Erysiphe polygoni* on *Phaseolus vulgaris* 'Pinto') and cucumber powdery mildew (*Sphaerotheca fuliginea* on *Cucumis sativus* 'Ashley') no THT was clearly demonstrated.

DISCUSSION

The simplest interpretation of the results might be that the rust fungus was killed because the tissues wilted severely but temporarily due to THI. Doak (1) reported that *Puccinia tritici* was killed by wilting of infected wheat plants.

Translocated heat therapy as reported here, seems to be an expected special case of THI and cold therapy. No application of THI or THT to practical disease control is recognized.

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