Cold Therapy of Bean Rust

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ABSTRACT

When bean leaves infected with rust (*Uromyces phaseoli* on *Phaseolus vulgaris* 'Pinto') for 3-6 days were dipped in ice water after heating at 45 C, the dosage of heat necessary for therapy was only about one-fourth of that necessary if the leaves were not dipped in ice water after heating. Cold alone was ineffective as a therapeutic agent. Phytopathology 64:1044-1046.

Heat may predispose plants to infection (2), may activate infections (5), and may cure infections (6). It is a common belief that after a specified heat treatment, the heated material should be immediately cooled (4). It might therefore follow that dipping plants in cold water immediately after heating would be a logical treatment to quickly terminate the heat treatment. Cold water treatment has proved effective in reducing injury from human burns (1). Surprisingly, this cold treatment may greatly increase the therapy of bean rust, as reported here.

Beans growing in 7.6 cm (3-inch) diam pots of a sand:peat:fertilizer mixture in the greenhouse were inoculated with rust at about 10 days after seeding. At various times after inoculations, the twin primary leaves were immersed in water at 45 C for a series of time intervals such as 4, 8, 12, 16, 20, 24, 36, 42, and 50 seconds.

Immediately after heating, one leaf of each pair (or one-half of each leaf) was immersed in ice water for 5 sec and the plants returned to the greenhouse bench. At about 15 days after inoculation, living rust was recorded on a scale of 0-10 (0 = no living rust pustules, 10 = normal rust development), and the dosage of heat for 50% therapy (ED_{50}) was estimated from interpolation of the records.

A typical treated leaf is illustrated in Fig. 1 and average results of all tests of this type are graphed in Fig. 2. There was a sharp division between the chilled and nonchilled portions of bean leaves. There was no apparent injury to the leaves from any of the treatments listed here. The dosage of heat for 50% therapy averaged about 30 sec at 45 C for the unchilled leaves and 10 sec at 45 C for the chilled leaves, but the necessary dosage for therapy was greatest for young and old infections.

Cold alone was not therapeutic, and rusted leaves were held for up to 2 h in ice water without apparent injury to the leaves, or clear suppression of rust. The duration of time between heating and chilling was critical. The greatest cold therapy resulted when the time from heating to chilling was about 1 sec, which was about the minimum time necessary to remove a leaf from hot water and place it in cold water. As this interval increased to 40 sec, cold therapy gradually disappeared. The duration of chilling was not critical. The shortest duration of dip in ice water was about 1 sec, and this was about as effective as dips of up to 30 sec duration. The chilling temp was also not critical. No difference was detected between chilling at 0 C and 3 C, but chilling at 10 C was significantly less effective. Cold therapy could be detected up to 15 C.

Cold therapy was also tested with the following infections: *Uromyces phaseoli* var. *vignae* on *Vigna sinensis*, *Erysiphe polygoni* on *Phaseolus vulgaris*, *Sphaerotheca fuliginea* on *Cucumis sativus*, cucumber mosaic virus on *Vigna sinensis*, and tobacco mosaic virus on *Cucumis sativus*. Cold therapy was clearly demonstrated with *Uromyces* on *Vigna*, but not with the other host-pathogen combinations. Cold injury was detected with leaves of *Phaseolus vulgaris*, *Vigna sinensis*, *Cucumis sativus*, *Stachys rigida*, and *Nicotiana tabacum*, and was best expressed in *Phaseolus* (8 sec at 55 C followed by ice water), but the dosage for injury was always greater than the dosage for therapy and this is another story.

How cold therapy works is not clear. It is likely a type of cold shock (3), but this also does not explain it. The important finding is that for rusted bean leaves given a sublethal dosage of heat, a 1 sec treatment at 0 C is equal in therapeutic value to 10-35 sec at 45 C. This is not true with certain other diseases and the application, if any, of this finding to practical disease control remains to be determined.

The phenomenon of cold therapy could be quantified as heat equivalents as above, or perhaps better as the ratios of ED values for heat therapy without cold treatment and with cold treatment. From the data in Fig. 2, this ratio is about 1.6 at 12 h after inoculation, 2.9 at 3 days, 4.4 at 6 days and 4.1 at 12 days.

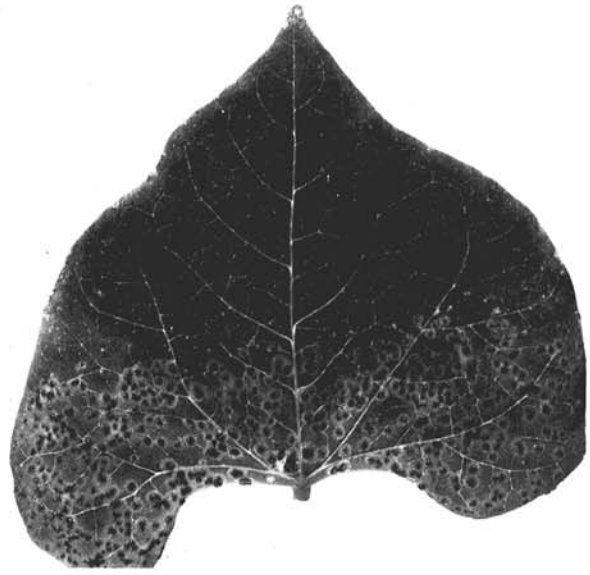

Fig. 1. Cold therapy of bean rust. This primary leaf was inoculated with rust on 15 December and treated 34 sec at 45 C on 21 December. The distal (upper) portion of the leaf was immediately dipped in ice water for 5 sec. Photographed 4 January. The killed 6-day-old rust pustules are still apparent on the chilled portion of the leaf.

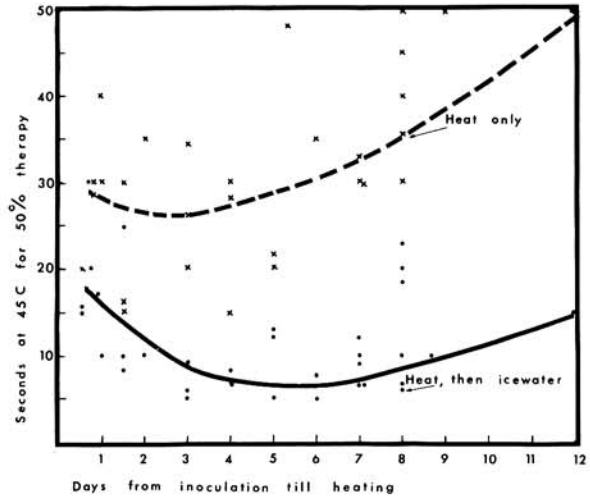

Fig. 2. Comparative therapy of bean rust when infected leaves were heated only, and when the heating was followed by 5 sec in ice water.

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