ENHANCED FUMIGANT ACTIVITY AT HIGHER SOIL TEMPERATURE

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In soil solarization, temperature increases are typically the greatest near the soil surface, and gradually diminish with depth. Consequently, soil solarization provides good pest control near the surface, and often inadequate suppression for deep layers. Soil solarization combined with fumigation at regular or reduced rates was found to substantially improve pest control compared to solarization or fumigation alone. The enhanced efficacy was caused by synergistic interactions between fumigants and temperature. Synergistic interactions between fumigants and temperature are potentially useful in that they may be used for designing integrated practices to improve the efficacy of solarization. In particular, if the synergism allows lower rates of fumigants to be used, environmental input of chemical fumigants will also be reduced. So far, however, fumigant-temperature interactions have not been systematically studied. The main objective of this study was to determine the interaction between soil temperature and activities of methyl bromide (MeBr) and 1,3-dichloropropene (1,3-D) against citrus nematode *Tylenchulus semipenetrans*.

Soil (50 g) in 170 mL glass bottles was inoculated with about 600 nematode juveniles extracted from infested citrus roots, and then exposed to MeBr and 1,3-D at 20, 30, 40, and 45°C. After exposure for 6, 12, 24, 48, and 96 h, replicate samples (× 4) were extracted on Baermann funnels and the remaining nematode density was enumerated. Two replicate samples were simultaneously removed for analysis of residual fumigant concentrations. Concentration-time index (ct) was calculated, and correlated with nematode mortality. Soil samples not treated with fumigants also received the same temperature treatments.

In untreated soil, nematode survival was not significantly affected by temperature in the range of 20-30ºC, but was strongly reduced at temperature ≥40°C (Figure 1). This suggests that temperatures ≥ 40°C were lethal for *Tylenchulus semipenetrans*, while a temperature ≤30°C was sub-lethal. In fumigated soil, nematode suppression was a combined result of fumigant activity and temperature effect. For the same fumigant rate, nematode suppression was closely dependent on the temperature of incubation (Figure 2). Nematode suppression at 40° in fumigated soils was similar to that in untreated soil, indicating that temperature alone was sufficient to provide the activity. Nematode responses to temperature were different between 20°C and 30°C. In general, much less time was required for the same rate to achieve 100% nematode suppression at 30°C than at 20°C. Likewise, at all levels, after exposure for the same time, greater suppression of nematodes occurred at 30°C than at 20°C. In contrast, in untreated soil, nematode survival was found to be unaffected at 20 and 30°C. This implies that synergistic reaction occurred between temperature and fumigant, which resulted in a higher fumigant activity at 30°C than at 20°C.

Temperature had a profound effect on the relationship between nematode suppression and *ct*, and similar trends were observed for both fumigants at both rates. For the same initial rate and after the same exposure to the fumigant, greater nematode suppression consistently occurred at 30°C than at 20°C. As soil temperature increased, lethal *ct*, the *ct* at which complete nematode elimination occurred, rapidly decreased (Figure 3). At 40°C, little or no fumigant was needed to kill the nematode, as temperature alone was sufficient. At 30°C, the lethal *ct* was only about 50% or less of that required at 20°C for both MeBr and 1,3-D.

The positive dependence of fumigant activity on soil temperature has implications for practical application. For instance, application of fumigants during soil solarization may overcome inadequate pest suppression in deep soil layers, thus improving the overall pest control throughout the soil profile. Use of reduced rates of fumigant may be possible because temperature in the subsoil layers is elevated, although not to the lethal level, by solarization. Such integration will also reduce the use and hence the environmental input of chemical fumigants as compared to fumigation alone. As pathogens residing near the surface are controlled by soil solarization, the volume of soil that needs fumigant exposure is smaller. The feasibility of such integration should be further evaluated with consideration of cost and applicability.

Figure 1. Nematode Suppression by Temperature in Untreated Soil

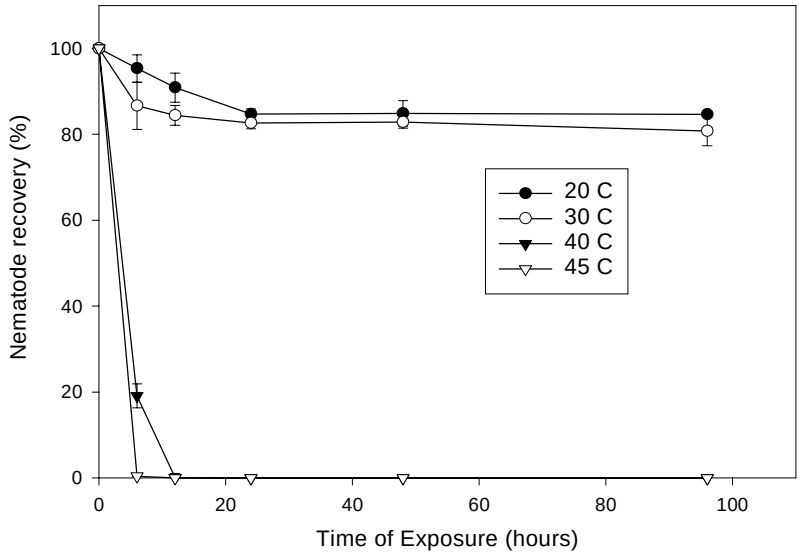

Figure 2a. Nematode Suppression by Temperature in MeBr Treated Soil

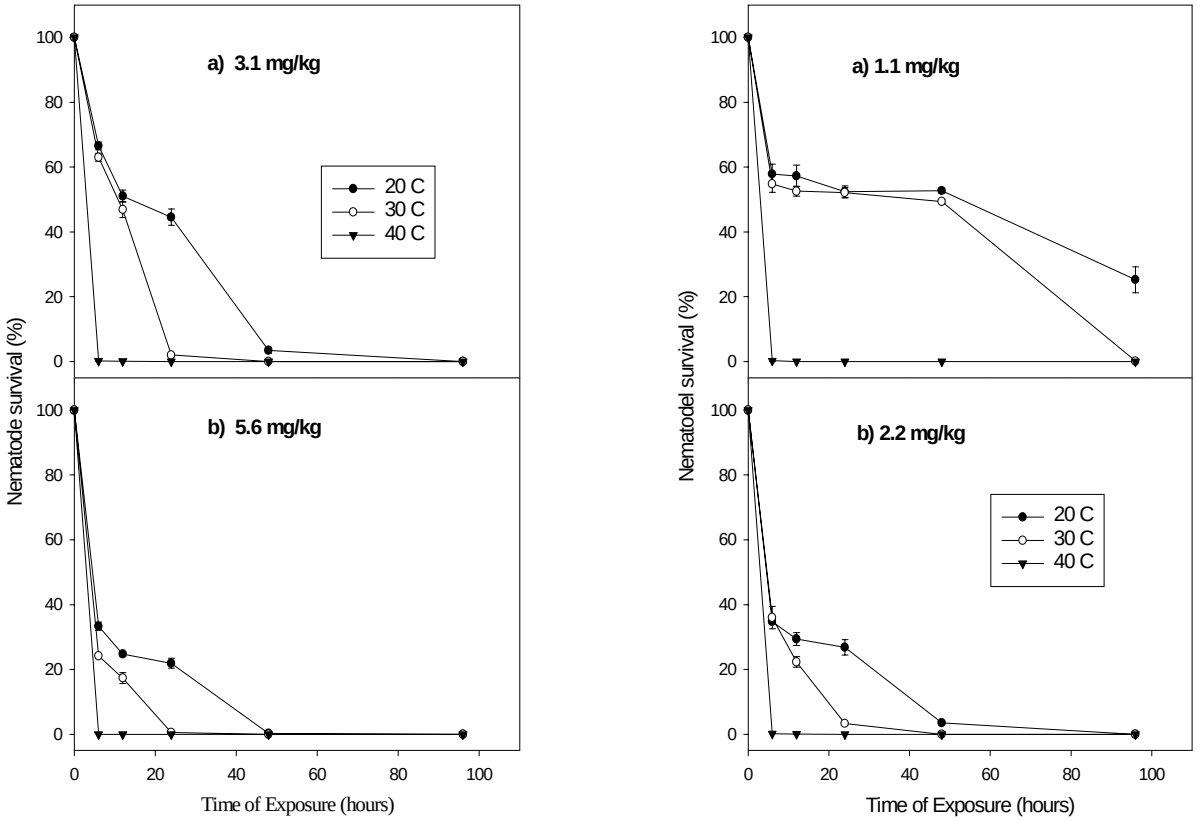

Figure 3. Dependence of Lethal CT on Temperature