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Using Capsaicin as a Less Toxic Insecticide©

Masanori Tomita and Hiroshi Endo
Agri Department, Ibigawa Kogyo Co., Ltd., Ikeda, Ibi-gun, Gifu, 503-2415, Japan
Email: tomita@ippsjapan.org

To evaluate capsaicin as a pest control material in plant cultivation, chili pepper 'Takano-tsume' (*Capsicum annum 'Parvo-acuminatum'*) was used as material for capsaicin extraction and research. The chili pepper extract was effective at decreasing the density of both spider mites and aphids. The mixture of chili pepper extract with a low concentration of neem extract was more effective. There were no negative effects on growth of seedlings when spraying chili pepper extract repeatedly.

INTRODUCTION

There are several advantages to using botanical insecticides rather than synthetic (conventional) insecticides (Rebek and Sadof, 2003). Botanical (plant-derived) insecticides are naturally occurring toxins extracted from plants. Generally they should pose less risk to human and environmental health than synthetic insecticides (Issacs et al., 2004). Some botanical pesticides are as toxic, or even more toxic, than some synthetic pesticides. Because many of them breakdown quickly in the environment, resulting in little risk of residues on food crops and less risk to beneficial insects. Therefore some materials can be used shortly before harvest, some are very pest specific and do little or no damage to other organisms, and still others such as bait stations minimize human exposure to the pesticide. Most botanicals are rapid acting and most, but not all botanicals, are of low to moderate toxicity to mammals. Because most botanical insecticides must be eaten by the insect pest, they are primarily harmful to these pests and do little harm to beneficial insects.

Botanical insecticides are often less damaging to the environment than conventional insecticides, and that is good, however they are still pesticides. Therefore all pesticides should be evaluated before selection for level of toxicity, effectiveness, environmental impacts, and costs.

Capsaicin is the material that is extracted from chili pepper (*Capsium annum* L.), and used as a botanical insecticide (Xu et al., 2005) especially for organic agriculture (Neumann, 2003). It can be used on ornamentals outdoors and indoors for control of aphids, spider mites, thrips, whitefly, and other pests. In usual use, capsaicin-containing products are primarily used to repel insects rather than to kill existing infestations. However, neither insecticidal effect nor the range of an effective concentration to a harmful insect of capsaicin is clear. The object of this investigation is to evaluate capsaicin as a pest control material in plant cultivation.

MATERIALS AND METHODS

Chili pepper 'Takano-tsume' (*C. annum 'Parvo-acuminatum'*) was used for the extraction of capsaicin. About 300 g of medium-sized dry peppers were soaked for 1 month in 4000 ml of 80% ethanol. After filtration, the solution was used to soak new dry peppers again for 1 month. After re-filtering, the solution was diluted and used for each experiment.

Two harmful insect species, commonly known as spider mites *(Tetranychus urticae* Koch) and cotton aphid (*Aphis gossypii* Glover), were collected in the field and used in the following experiments:

1. **Effect of concentration of chili pepper extract on survival rate of harmful insects.** The insects were divided into nine groups which contained 15 insects. Each group was placed in a 9-cm-diameter petri dish containing moistened filter paper. One group of petri dishes was subjected to three bursts from a spray bottle containing water only which served as a control. Other groups of Petri dishes were subjected to three bursts from the spray bottle containing the pepper extract. Insects were maintained in their respective Petri dishes for 24 h at 25 °C under dark condition, after which counts were made to determine the number of aphids surviving for each group. Significant differences in survivorship were compared for each species using a ×4 test of independence.
2. **Effect of concentration of chili pepper extract on numbers of harmful insects under greenhouse condition.** The diluted chili pepper extracts (×10 to ×50) or water was sprayed at 3-day intervals on greenhouse plants which were damaged by harmful insects (spider mites or aphids). For research on aphids, a chemical treatment (chemical control) was sprayed containing 0.01% dinotefuran [(EZ)-(RS)-1-methyl-2-nitro-3-(tetrahydro-3-furylmethyl) guanidine: nitroguanidine insecticide].
3. **Effect of interval time of spraying of chili pepper extract supplemented with or without neem extract, on numbers of aphids on shoots of florist's chrysanthemum.** The diluted chili pepper extracts (×20) supplemented with (or without) neem extract (3 ppm AZA) (Tomita and Endo, 2007) or water as control were sprayed at 3-, 7-, or 14-day intervals on shoots of florist's chrysanthemum which were damaged by aphids.
4. **Effect of interval spraying of chili pepper extract on fresh weight of some vegetable seedlings.** To clarify the effect of chili pepper extract on plant growth, five species of vegetables were used for examination. Seedlings of lettuce (*Lactuca sativa* L.*)*, common basil (*Ocimum basilicum* L.*)*, 'Komatsuna' (*Brassica rapa* var. *peruviridis* L.), 'Shun-giku' (*Chrysanthemum coronarium* L.), and table beet (*Beta vulgaris* L.) were planted in a 9-cm-diameter pot and cultured under greenhouse conditions. After 3 days of planting, the diluted chili pepper extracts (×20) or water were sprayed at 3 or 7 days intervals on shoots of each seedlings. After 5 to 8 weeks of culture, the growths of seedlings were evaluated.

RESULTS AND DISCUSSION

1. **Effect of concentration of chili pepper extract on survival rate of harmful insects.** Results are shown in Fig. 1. Both the aphids and spider mites were dead after 24 h when exposed to higher concentrations of chili pepper extracts. No insects in the

water control died during this period. Based on this experiment it was concluded that 'Takano-tsume' pepper extract has the ability to kill harmful insects under the controlled laboratory conditions: direct contact with the pepper extract and continuous exposure to this extract for 24 h.

2. **Effect of concentration of chili pepper extract on numbers of harmful insects under greenhouse condition.** The insects were released repeatedly on greenhouse plants, spider mites on florist chrysanthemum, and aphids on silver lace, respectively, and established (Figs. 2, 3). Results were summarized for spider mites (Fig. 4) and for aphids (Fig. 5). The higher the concentration of chili pepper extract, the higher the repellent effect was on both insects. Chemical insecticide was effective for killing aphids; however, interval spraying of chili pepper extract was effective in keeping the harmful insect suppressed.
3. **Effect of interval spraying of chili pepper extract, with or without neem extract, on numbers of aphids on shoots of florist chrysanthemum.** Results are shown in Fig. 6. Neem extract was effective in suppressing harmful insects, however, it caused growth inhibition of plants under high concentrations (over 10 ppm AZA, and it was insufficient on the repellent effect under low concentration (Tomita and Endo, 2007). In this experiment, the chili pepper extract was also effective at decreasing the density of aphids. The mixture of chili pepper extract with low concentration of neem extract was the most effective at repelling aphids and this result may compare favorably with the synthetic insecticide on aphids suppression.
4. **Effect of interval spraying of chili pepper extract on fresh weight of some vegetable seedlings.** Results were summarized in Fig. 7. There were no negative effects on fresh weight of five vegetable seedlings when spraying chili pepper extract repeatedly. Although more detailed examinations are necessary, these results shows that using chili pepper extract would enable pest management that is more environmentally healthy than ordinary methods.

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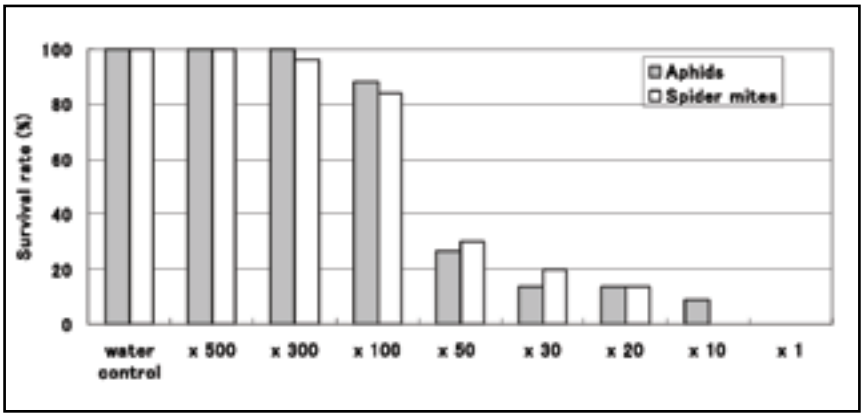

Figure 1. Effect of concentration of chili pepper extract on survival rate of harmful insects.

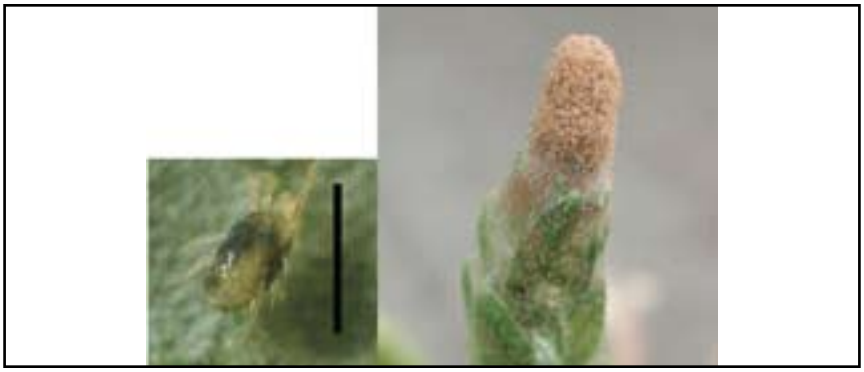

Figure 2. Spider mites *(Tetranychus urticae* Koch) (Left; Bar = 0.5 mm) and its colony on shoot of florist's chrysanthemum (Right).

Figure 3. *Aphis gossypii* Glover (Left; Bar = 1.0 mm) and its colony on shoot of *Chrysanthemum cinerariifolium* 'Silver Lace' (Right).

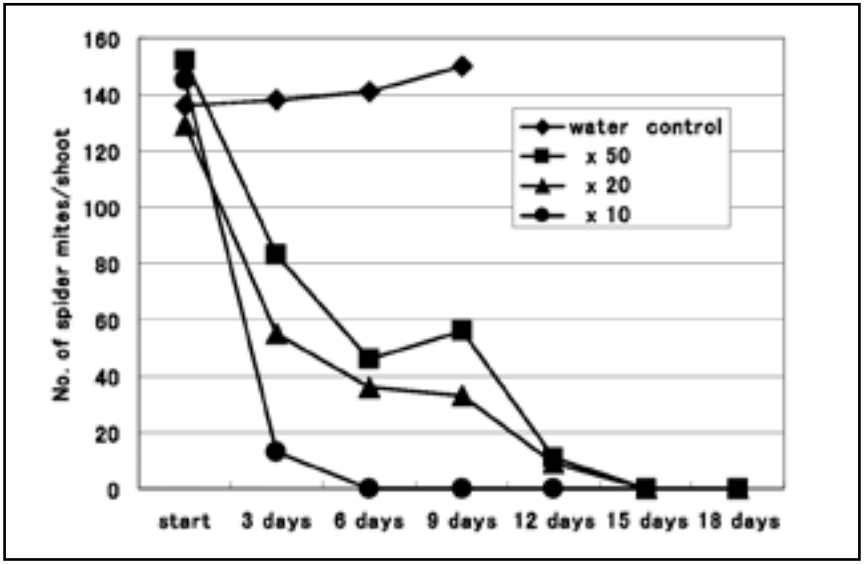

Figure 4. Effect of concentration of chili pepper extract on numbers of spider mites on *Chrysanthemum* ×*morifolium* (florist's chrysanthemum).

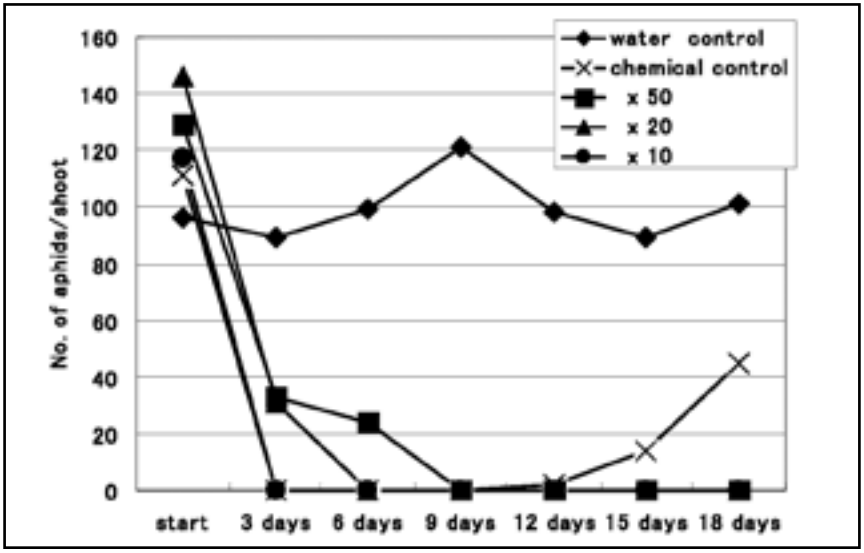

Figure 5. Effect of concentration of chili pepper extract on numbers of aphids on shoots of *Chrysanthemum cinerariifolium* 'Silver Lace'. Chemical control: sprayed 0.01% 'dinotefuran' [(EZ)-(RS)-1-methyl-2-nitro-3-(tetrahydro-3-furylmethyl) guanidine: nitroguanidine insecticides] at once.

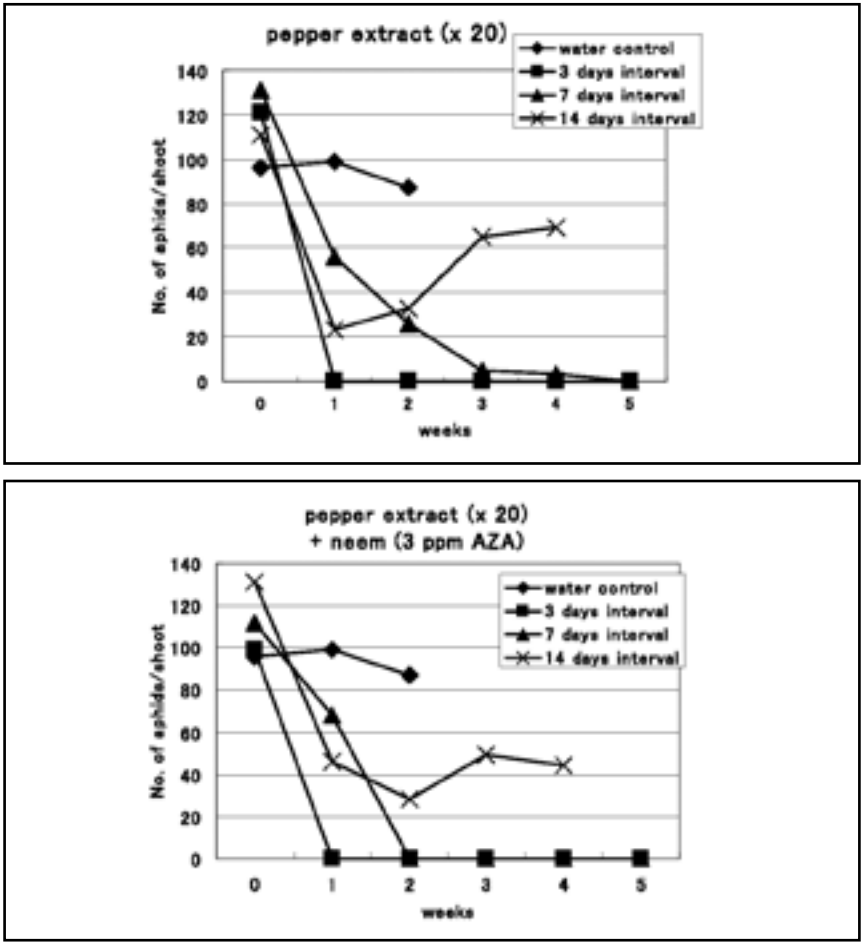

Figure 6. Effect of interval spraying of chili pepper extract supplemented with or without neem extract, on numbers of aphids on shoots of florist's chrysanthemum.

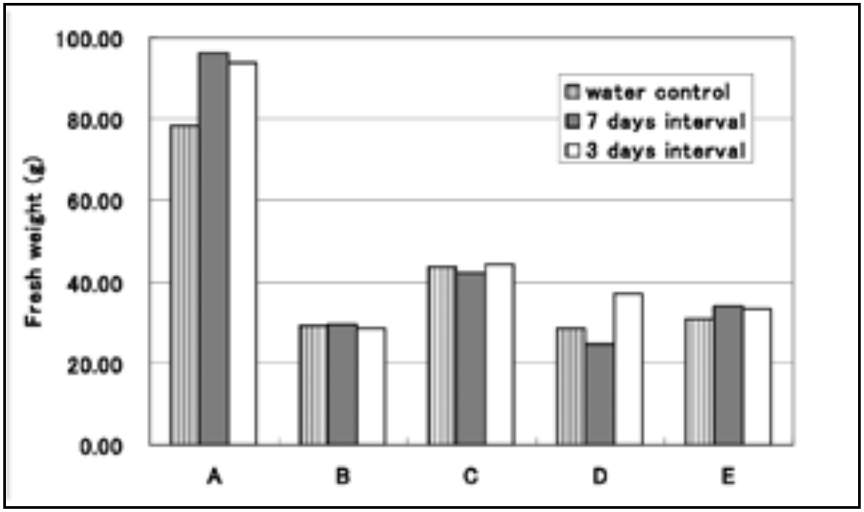

Figure 7. Effect of interval spraying of chili pepper extract on fresh weight of some vegetable seedlings. A: Lettuce (*Lactuca sativa*), B: Basil (*Ocimum basilicum*), C: 'Komatsuna' (*Brassica rapa var. peruviridis*), D: 'Shun-giku' (*Chrysanthemum coronarium*), E: Table beet (*Beta vulgaris* L.).