台灣昆蟲 26: 379-390 (2006)
Formosan Entomol. 26: 379-390 (2006)

Effects of Household Soap Solutions on the Mortality of the Two-spotted Spider Mite, *Tetranychus urticae* Koch (Acari: Tetranychidae)

Chi-Yang Lee*, Kang-Chen Lo, and Me-Chi Yao
Applied Zoology Division, Agricultural Research Institute, Council of Agriculture, Executive Yuan, Taichung 413, Taiwan
Wu-Kang Peng, and Wen-Jer Wu Department of Entomology, National Taiwan University, Taipei 106, Taiwan

ABSTRACT

We assessed the control effect of soap solutions on the two-spotted spider mite, *Tetranychus urticae* (TSM). Five kinds of soap solutions (4 g/l) made from different household soaps were evaluated by contact and residual bioassays on the adults and eggs of TSM in the laboratory. The mortality rates of female adults immersed in 5 soap solutions for 1 to 8 s showed no significant differences among them. Mortality rates of treatment with soap (4 g/l) in distilled water or that with abamectin (0.01 g (AI)/l) also exhibited no significant differences. Mortality rates of female adults ranged from 93.1 to 98.6% among the five soap solutions and that of the abamectin solution was 100%. Soap solutions did not significantly affect the mortality rates of TSM egg, and a dual dipping did not kill the remaining nymphs. The mortality rates of nymphs ranged from 89.2 to 98.8% among soap solutions dips. A soap residual bioassay showed that soap dry film did not significantly affect the mortality rates of female adults. Divalent metal ion concentrations in the soap solution may affect the activity on TSM. The mortality rates of female adults treated with soap solution dissolved in standard hard water was significantly lower than that dissolved in distilled water.

Key words: *Tetranychus urticae*, soap solution, bioassay, standard hard water

Introduction

The two-spotted spider mite (TSM), *Tetranychus urticae* Koch (Acari: Tetranychidae) is a worldwide economic pest in greenhouses and in the field (Helle and Sabelis, 1985). It was found in late 1970s and becomes one of the 10 major mite pests in Taiwan (Chang and Chen, 1984; Ho, 1988; Lo and Chen, 1995; Ho, 2000). It is frequently found on papaya, watermelon, melons, cucumber,

*Correspondence address
e-mail: cylee@wufeng.tari.gov.tw

eggplant, pear, apple, peach, strawberry, rose, and chrysanthemum (Ho *et al.*, 1995; Fei and Wang, 2004; Lu and Wang, 2005). Control measures to the present have mainly depended on the use of acaricides (Fei and Wang, 2004). The chemical measures against spider mites often resulted in vain due to acaricide resistance developed in population (Chang and Chen, 1984; Ho, 2000). Efforts to control it using biological control or non-pesticidal techniques have been developed (Lo *et al.*, 1984; Lee and Lo, 1989; Lo *et al.*, 1993; Chang and Huang, 1995; Lo and Chen, 1995; Wang and Liu, 1996; Shih, 2001). However, the cost effectiveness was not acceptable. In order to achieve satisfactory control, it is necessary to reduce spider mites to a low population density before releasing the predatory mites. Among the alternative methods to replace acaricides, soap is one of the most convenient materials. Furthermore, no pesticide measurement is allowed to be used in organic agriculture in Taiwan (Anonymous, 2003).

Soap solution for the control of plant soft-bodied pests, such as aphids, spider mites, and mealybugs was used as early as 1787 (Ware and Whitacre, 2004). The interest in soap was lost due to the advent of effective synthetic organic insecticides. In the early 1970s, soap was used to control aphids on landscape shrubs along highways by the California Department of Transportation, which provoked renewed interest in soap research as a pest control measure (Pinnock *et al.*, 1974). The use of soap for the control of *T. urtiace* was carried out in the 1980s. Osborne (1982) studied the efficacy and phytotoxicity associated with soap used for mite control on tropical ornamental foliage plants grown in environments such as restaurants, hotels, and shopping malls. Osborne (1984) found the effectiveness of insecticidal soap (6.2 or 12.4 g (AI)/l) was good as dienochlor (0.3 g (AI)/l) against TSM infesting *Brassaia actinophylla* in the greenhouse. Osborne and Petitt (1985) conducted studies that indicated an overall benefit using a combination of insecticidal soap and predators (*Phytoseiulus persimilis*) when compared to the use of predators alone. He suggested that the potential existed for the integration of these two control tactics. Up to now, research results from insecticidal soap indicate that they have been found effective against TSM (Puterka *et al.*, 2003; Chiasson *et al.*, 2004a). Among the research discussed above, insecticidal soap was the focus of attention. However, there is little written about household soap.

The purpose of this study was to evaluate the effect of household soaps on TSM. Five kinds of soap solutions made from different household soaps were evaluated using contact and residual bioassays on the adults and eggs of TSM in the laboratory.

Materials and Methods

Colony sources and experimental conditions

The TSM colony used in this study originated from a strawberry crop at National Taiwan University, Taipei, Taiwan, and had been reared since 1970s. A colony has been maintained on a native soybean variety, Chin-pe Tou (*Glycine max* L.), in the greenhouse. Mites were transferred to kidney beans, *Phaseolus vulgaris* L., 2 months before a series of tests at the beginning of 2005, and reared in the laboratory at 25 ± 1ºC, 40-70% RH, and photoperiod of 14: 10 (L: D) h. Female adults were first transferred to bean leaf discs (3 cm diameter) and allowed to lay eggs for 24 h at 30 ± 1ºC and 40-70% RH, and photoperiod of 14: 10 (L: D) h in the laboratory. Then, female adults were removed from the bean leaf discs. The eggs on the discs were still kept in the laboratory for 2 days, and then transferred to the seedlings of kidney beans (9-14 days old after sowing) in 500-ml plastic cups. The larvae hatched and crawled onto the seedlings and fed on leaves for another 5 days. All 2-d female adults used in this test were obtained on day 9. Eggs in this test were obtained in the same way within 24 h as described above.

The bean leaf disc was placed bottom side up on moistened cotton in a plastic Petri dish (9 cm diameter). Mortality rates of female adults were evaluated with 144 female adults (four replicates with 36 mites per replicate, and each replicate contained three bean leaf discs with 12 mites per bean leaf disc) in each test. Five kinds of household soap (1. Tai Shin soap, Tai Shin Industrial Co., Taipei County; 2. Chung Hsing soap, Chung Hsing Soap Factory, Changhua County; 3. Morita natural laundry soap, Morita Biotech Corp., Changhua City; 4. Nam Chow soap, Nam Chow Group, Taoyuan County; and 5. Pao Hong soap, Pao Hong Chemical Industry Co., Changhua County) were used for tests and an additional chemical of abamectin (The Arab Pesticides & Veterinary Drugs Mfg. Co., Amman, Jordan) was chosen for a standard acaricide. All of these test materials were purchased from local retailers. Soaps and abamectin were individually diluted with distilled water to the desired concentrations. In the test of standard hard water, the hard water of 342 ppm and pH value of 6.0-7.0 was prepared according to processes of CIPAC (Anonymous, 1995). The ratio of calcium ion to magnesium ion concentrations was 4:1. An solution of abamectin was made at the recommended concentration (2% EW, 2000x, 0.01 g (AI)/l). The bean leaf disc was dipped in designed solution of soap, abamectin, or a distilled water. The solution (1000 ml) was kept in a beaker under stirring phase (60 x 8 mm dia. at 100 rpm) when the bean leaf disc was dipped into the solution. After dipping and 24 h elapsed, mites that ran off or did not respond to a touch (or touches) with a fine brush were considered dead. All tests were conducted at 25 ± 1°C, 65 ± 5% RH, and 24 h photophase lights in the growth chambers. Mites were inspected and counted under a binocular microscope.

Effect of household soap on TSM

To evaluate the effect of immersion duration on the mortality of female adults, the 2-d female adults transferred to the bean leaf discs were first kept in the laboratory for 60 min. Then, immersed individually the leaf discs in prepared solution for 1, 2, 4, and 8 seconds, and kept each of them up side down on a piece of cotton in the Petri dish. After dipping, mites remaining on the bean leaf discs were counted. A few mites washed away by the water were not incorporated into the mortality calculations. There were at least 30 female mites were evaluated and collected in each test for each replicate. And then the mites were placed in the growth chamber. The mortality of female adults was assessed and recorded 24 h after treatment.

To evaluate the effect of different kinds of soap concentrations on the mortality of female adults, the concentrations of 0.25, 0.5, 1, 2, 4 g/l of soap solution and distilled water control were used to test the mortality of mites. The bean leaf discs with female adults were dipped in each soap solution for 1 s.

To evaluate the effect of soap in hard water solutions on the mortality of female adults of TSM, we prepared standard hard water first and soap solution of 4 g/l. The bean leaf discs with female adults were dipped in each soap solution for 1 s.

To evaluate the effect of soap dry film on the mortality of female adults, we prepared the soap solution of 4 g/l. The bean leaf discs were dipped in each aqueous solution of soap or distilled water for 1 s, dried for 60 min, and placed bottom side up on moistened cotton in a Petri dish. Female adults were transferred to the bean leaf discs. After 60 min, mites remaining on the bean leaf discs were counted then placed in the growth chamber. The mortality of female adults was assessed and recorded 24 h after treatment.

To evaluate the effect of the soap solutions on the mortality of immature TSM, there were at least 200 eggs (four replicates with at least 50 eggs per replicate) at 0-24 h old in each test, and the concentration tested was 4 g/l. The bean leaf discs were dipped for 1 s in each aqueous solution of soap or the control. After dipping, eggs remaining on the bean leaf discs were counted then placed on seedlings (9-14 days old after sowing) of kidney bean in 500-ml plastic cups. The seedlings were put into the growth chamber for 7 days. During this period, the larvae hatched and crawled to the seedlings and fed on the leaves. Eggs which did not hatch were considered dead and nymphs were counted. A dual dipping was conducted in which bean seedlings were dipped for 1 s in each aqueous solution of soap or the control. After dipping, nymphs remaining on the bean seedlings were counted, and then placed in the growth chamber. The mortality of nymphs was evaluated 24 h after treatment.

Statistical analysis

All data on the mortality (percentages) in each experiment were corrected using Abbott's formula (Abbott, 1925) and transformed using arcsine square root before analysis. Mortalities were analyzed using analysis of variance (ANOVA) and were separated using Tukey's studentized range test following a significant F test (SPSS, 1999).

Results

The mortality rates of female TSM adults immersed in the soap solution for 1, 2, 4, and 8 seconds are shown in Fig. 1. There are no significant differences in the mortality rates among treated female adults (Tai Shin soap, $F = 0.526$, df = 3,12, $p = 0.673$; Chung Hsing soap, $F = 0.478$, df = 3,12, $p = 0.704$; Morita natural laundry soap, $F = 0.092$, df = 3,12, $p = 0.963$; Nam Chow soap, $F = 1.051$, df = 3,12, $p = 0.406$; and Pao Hong soap, $F = 0.601$, df = 3,12, $p = 0.627$). The low mortality rate of 93.1% was occurred in the treatment of Pao Hong soap solution for 1 s, which the others were all > 96.5%. The results indicated that household soap dissolved in the distilled water is effective against female adults. Mortality rates of water dipping increased with the immersion duration increased (1-8 s) by increasing mortality rates from 4.3 to 13.9%.

The effects of different kinds of soap concentrations on the mortality of female TSM adults are shown in Fig. 2. Mortality rate of mites dipped with soap solution at concentrations either of 2 or 4 g/l produced no significant differences except for Nam Chow soap (83% at a concentration of 2 g/l), which was significantly lower than the 97.9% at a concentration of 4 g/l (Tai Shin soap, $F = 62.089$, df = 4,15, $p < 0.001$; Chung Hsing soap, $F = 55.546$, df = 4,15, $p < 0.001$; Morita natural laundry soap, $F = 31.161$, df = 4,15, $p < 0.001$; Nam Chow soap, $F = 32.829$, df = 4,15, $p < 0.001$; and Pao Hong soap, $F = 95.630$, df = 4,15, $p < 0.001$). The mortality of mites was significantly lowered at the lower concentrations of 0.25 and 0.5 g/l.

The mortality rates of female TSM adults treated with soap dissolved in distilled water or in standard hard water are shown in Fig. 3. The high concentration of soap (4 g/l) dissolved in distilled water showed high mortality rate and no significant differences to that of abamectin ($F = 101.895$, df = 12,39, $p < 0.001$). The

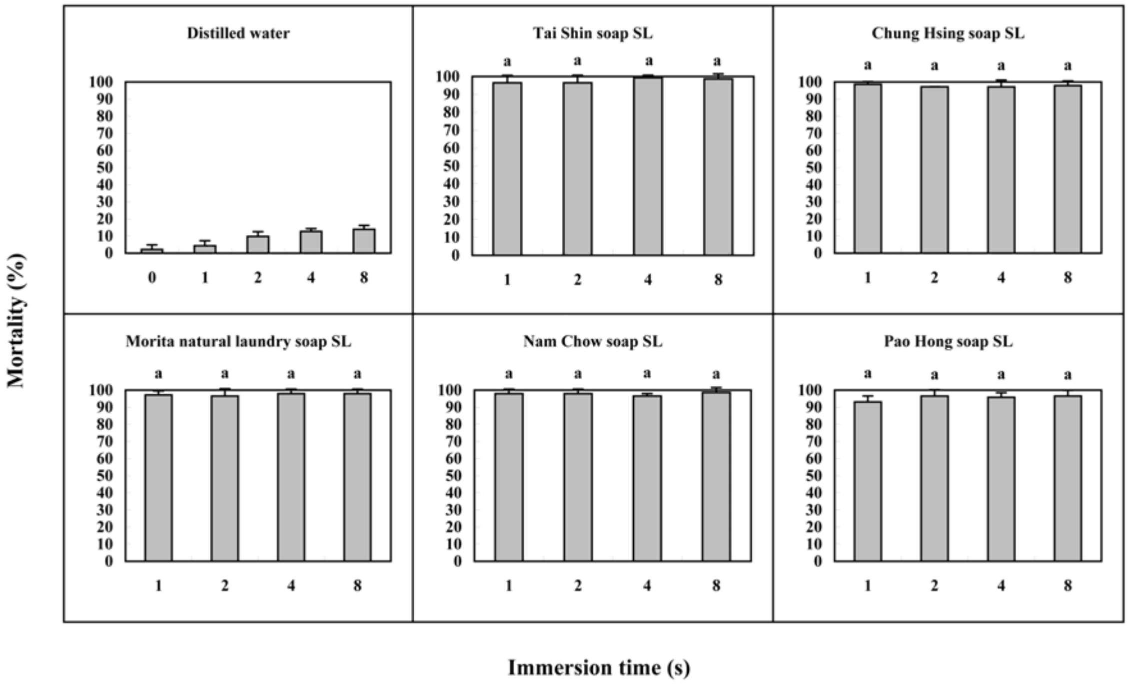

Fig. 1. Effects of immersion duration of soap solutions (SLs) (4 g/l) on the mortality of female *Tetranychus urticae* adults. Means with the same letter do not significantly differ in a given chart by Tukey's studentized range test at $p \leq 0.05$.

mortality rates of female adults dipped in soap solution with standard hard water, ranged from 17.4 to 31.9%, and they were significantly lower than that of soap dissolved in distilled water.

The mortalities of female TSM adults affected by soap dry films ranged from 2.1 to 11.7%. The mortality rates of female adults treated on the different kinds of soap dry films were significantly lower than that of abamectin (F = 79.267, df = 6,21, $p < 0.001$) (Fig. 4). The mortality rates of TSM eggs caused by soap solutions ranged from 9.8 to 15.8%. Different kinds of soap solutions did not significantly vary the egg survivals at a concentration of 4 g/l (F = 10.768, df = 6,21, $p < 0.001$) (Fig. 5). The mortality rates of nymphs caused by soap solutions ranged from 89.2 to 98.8% (Fig. 6). The mortality rates of nymphs treated with Chung Hsing soap solution and Pao Hong soap solution showed no significant differences to that with abamectin solution, but the mortality rates of nymphs in the treatment with Tai Shin soap solution, Morita natural laundry soap solution, and Nam Chow soap solution were significantly lower than that with abamectin solution (F = 74.973, df = 6,21, $p < 0.001$) (Fig. 6).

Discussion

The duration of immersion duration reported and designed to evaluate chemicals on mites was varied from 2 to 10 s (Anonymous, 1974; Osborne and Petitt, 1985; Zhang and Sanderson, 1990; Curkovic and Araya, 2004) to ensure complete wetting of mites. In this paper, the duration by immersing female TSM adults in soap solution are 1 to 8 s and results showed

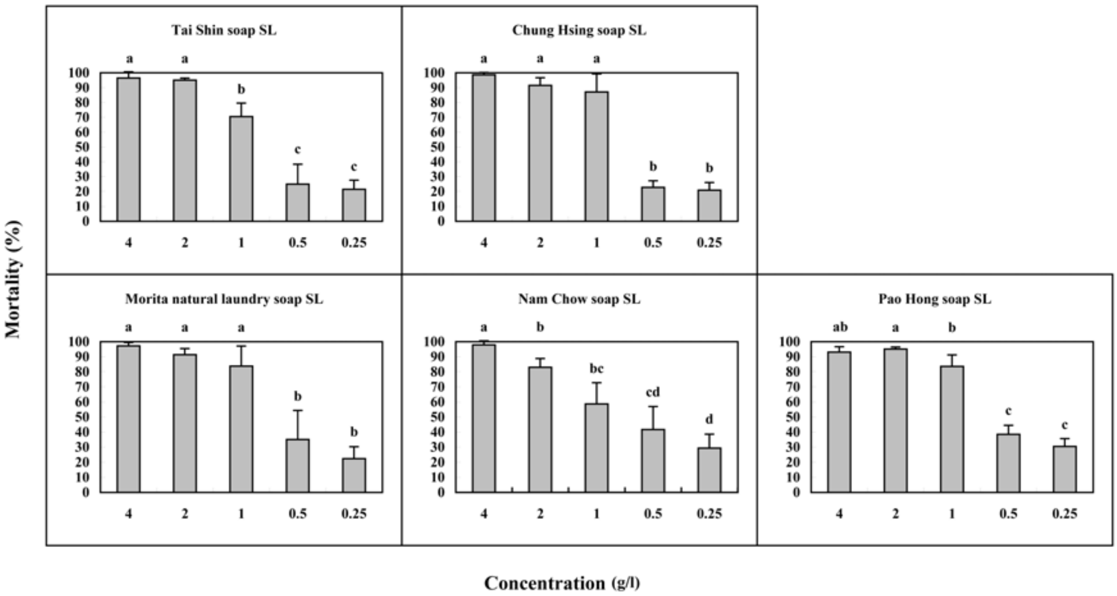

Fig. 2. Effects of types of soap and their concentrations on the mortality of female *Tetranychus urticae* adults. Means with the same letter do not significantly differ in a given chart by Tukey's studentized range test at $p \leq 0.05$.

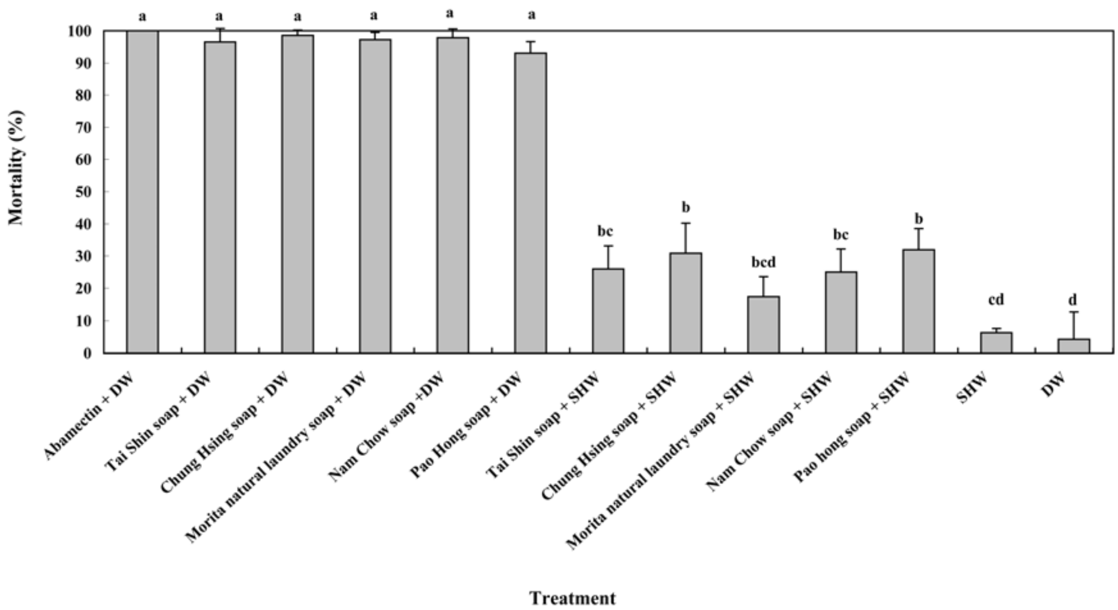

Fig. 3. Effects of soap solution with distilled water (DW) and standard hard water (SHW, 4 g/l) and abamectin on the mortality of female *Tetranychus urticae* adults. Means with the same letter do not significantly differ by Tukey's studentized range test at $p \leq 0.05$.

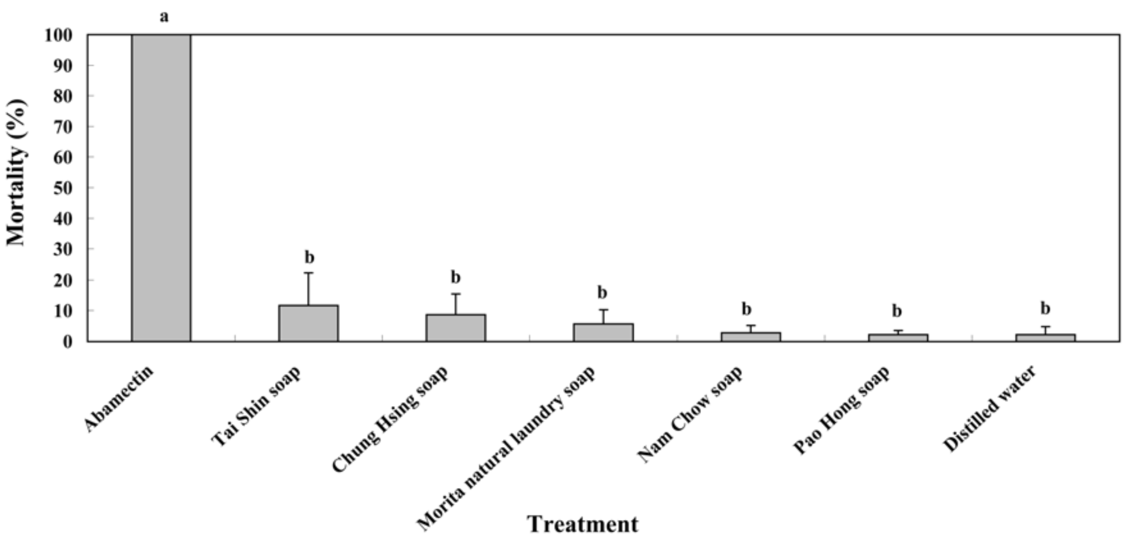

Fig. 4. Effects of soap dry films and abamectin on the mortality of female *Tetranychus urticae* adults. Means with the same letter do not significantly differ by Tukey's studentized range test at $p \leq 0.05$.

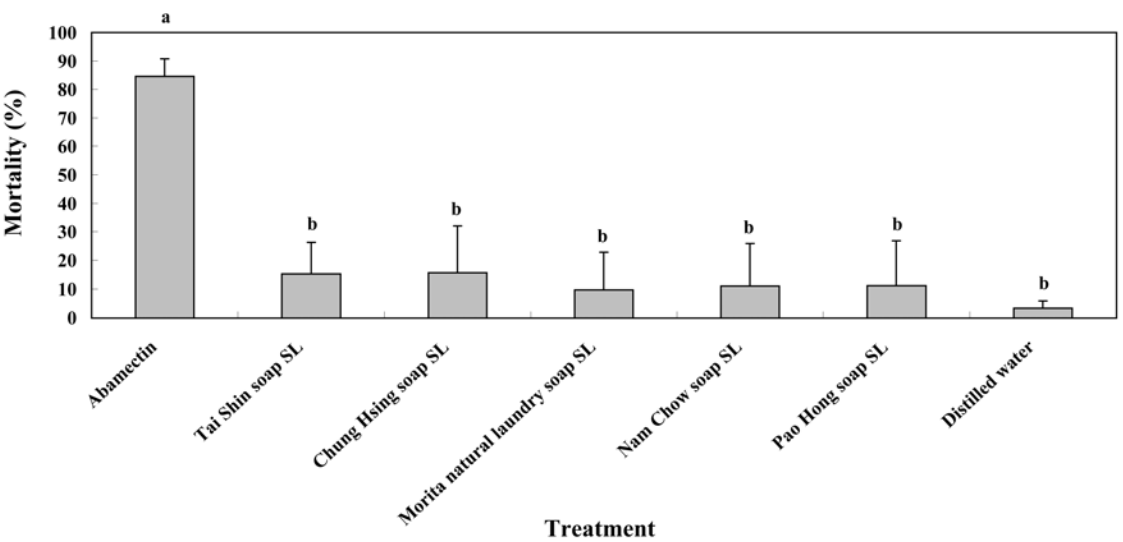

Fig. 5. Effects of soap solutions (SLs) (4 g/l) and abamectin on the mortality of *Tetranychus urticae* eggs. Means with the same letter do not significantly differ by Tukey's studentized range test at $p \leq 0.05$.

no significant differences between mortality rates. This result indicated that the immersion duration (1 to 8 s) was not important to mite mortality tests. Imai *et al*. (1995) studied the activity of insecticidal soap on *Myzus persicae* (Sulzer), and indicated that humidity greatly affected aphid mortality rates. The mechanism of the soap toxicity was a long coverage of the respiratory system by a film of a highly wettable and slowly evaporating solution which caused suffocation

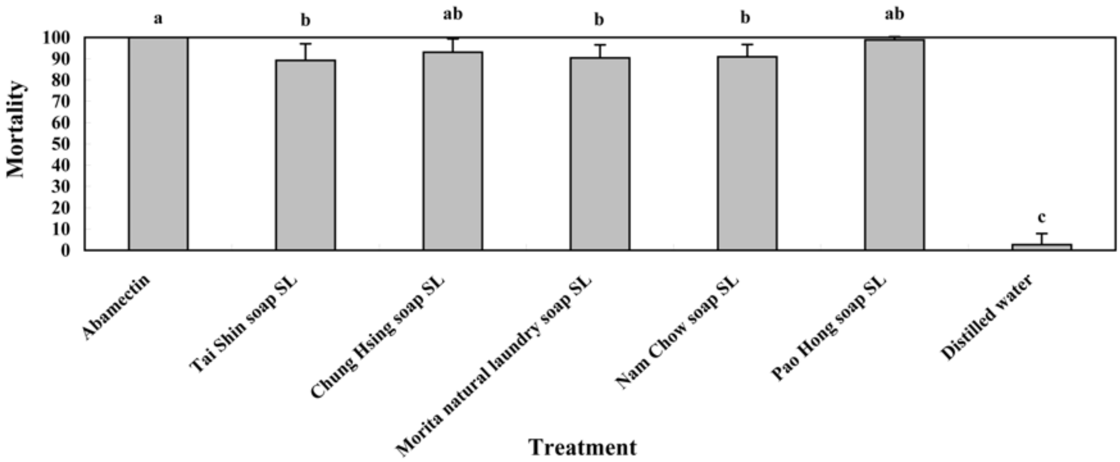

Fig. 6. Effects of soap solutions (SLs) (4 g/l) and abamectin on the mortality of *Tetranychus urticae* nymphs. Means with the same letter do not significantly differ by Tukey's studentized range test at $p \leq 0.05$.

of insects or mites. Water can also kill the mites. Mortality rates of the control ranged from 4.3 to 13.9% (Fig. 1) which indicated that immersion duration of < 8 s was not a significant lethal factor. Tulisalo (1974) reported that when female TSM adults were immersed in water for 24 and 48 h, the mortalities were 36.6% and 54.5%, respectively. Duso *et al.* (2004) suggested that TSM populations could be reduced by contacting misted water on greenhouse cucumbers. In other species studied, Curkovic and Araya (2004) indicated that the mortalities of *Panonychus ulmi* (Koch) and *P. citri* (McGregor) immersed in water for 2-4 s using a leaf-dip technique were 6.8% and 18.8%, respectively.

Divalent metal ion concentrated in the water could lower the effects of soap on insects (Ginsburg, 1935). Imai *et al.* (1997) studied the effect of water hardness on the activity of insecticidal soap for *Myzus persicae* (Sulzer). The effect of distilled water and soap solution on aphid did not significantly differ from solution of soap dissolved in 41.7-417 ppm hard water, but a significant difference was observed at 500 ppm hard water solution. The mortality of any kind of 5 soaps dissolved in standard hard water (342 ppm) was significantly lower than that of the same soap dissolved in distilled water (Fig. 3).

Soap solution has been used for controlling insects and mites since 1787 (Ware and Whitacre, 2004), and several commercial insecticidal soaps have been sold for decades. However, insecticidal soap is more popular than household soaps, because the blend of fatty acids is not consistent among domestic brands and correct dilutions cannot be determined. Five kinds of household soap dips were evaluated. The mortality rates of female TSM adults treated with any kind of soap dips (4 g/l) dissolved in distilled water showed no significant difference among them so was to that of abamectin (Fig. 3). Thereby, the results suggest that soap solution can be used to replace acaricides against TSM. Household soap dry films did not showed a significant effect on the mortality rates of female adults (Fig. 4). Osborne (1984) reported that soap dry film had residual toxicity on TSM, and they observed that mites moved from soap-treated plants to water-treated plants.

Household soap solutions did not

significantly affect the mortality rates of TSM egg (Fig. 5), and a dual dipping did not kill the remaining nymphs. The mortality rates of nymphs ranged from 89.2 to 98.8% among soap solutions dips (Fig. 6). Apparently, a tactic combining soap with biological agents or biorational acaricides should be further studied (Osborne and Petitt, 1985; Puterka *et al.*, 2003; Chiasson *et al.*, 2004a).

In terms of crop protection, farmer should protect not only his crops from injury by pests but also humans and the environment from hazards of chemicals or residues. Osborne and Petitt (1985) recommended an integrated control of using insecticidal soap and predators (*P. persimilis*). Kaya *et al.* (1995) conducted a study of a measure combining *Heterorhabditis bacteriophora* or *Steinernema carpocapsae* with a pesticidal soap (M- Pede) effective and the measure against the spotted cucumber beetle larvae *Diabrotica undecimpunctata* in soil, and all feeding stages of the cabbage aphid *Brevicoryne brassicae* on foliage. Stewart *et al.* (2002) incorporated insecticidal soap into an integrated pest management (IPM) program, which was successful in reducing pesticide use and costs.

Although household soap can be considered a contact acaricide, soap should be carefully used in pest control. Soap may cause phytotoxicity on some plant species (Moore *et al.*, 1979; Osborne, 1982, 1984) and kills some beneficial insects or predatory mites (Moore *et al.*, 1979; Osborne and Petitt, 1985; Smith and Krischik, 2000; Chiasson *et al.*, 2004b). Further studies are needed to reconfirm the mechanisms of soap on insects to minimize its side effects.

Acknowledgments

We thank Dr. Chain-Ing Shih of National Chung Hsing University, for valuable comments on the manuscript. We thank Dr. Ju-Chun Hsu of the Taiwan Agricultural Chemicals and Toxic Substances Research Institute, for technical assistance and preparing the standard hard water. We thank Dr. Liang-Gi Yao of Taiwan Semiconductor Manufacturing Co., for valuable comments on the manuscript. We thank Miss Yu-Ling Hsu, Miss Mei-Ying Liu, and Miss Chu-Ying Chang, for performing the rearing and bioassay procedures.

References

Abbott, W. S. 1925. A method of computing the effectiveness of an insecticide. J. Econ. Entomol. 18: 265-267.

Anonymous. 1974. Recommended methods for detection and measurement of resistance of agricultural pests to pesticides. Tentative methods for spider mites and their eggs, *Tetranychus* spp. and *Panonychus ulmi* (Koch). FAO Plant Prot. Bull. 22: 103-107.

Anonymous. 1995. CIPAC Handbook F. Physio-chemical Methods for Technical and Formulated Pesticides. Collaborative International Pesticides Analytical Council Limited, Hertfordshire, UK. 472 pp.

Anonymous. 2003. Production Standards for Organic Agricultural Products - Crops. Council of Agriculture, Executive Yuan, Taipei, Taiwan.

Chang, C. P., and S. C. Huang. 1995. Evaluation of the effectiveness of releasing green lacewing, *Mallada basalis* (Walker) for the control of tetranychid mites on strawberry. Plant Prot. Bull. 37: 41-58. (in Chinese)

Chang, H. Y., and C. N. Chen. 1984. Review of the mite problems and their biological control in Taiwan. Natl. Taiwan Univ. Phytopathol. & Entomol. 11: 137-156. (in Chinese)

Chiasson, H., N. J. Bostanian, and C. Vincent. 2004a. Acaricidal properties of a *Chenopodium*-based botanical. J. Econ. Entomol. 97: 1373-1377.

Chiasson, H., C. Vincent, and N. J.

Bostanian. 2004b. Insecticidal properties of a *Chenopodium*-based botanical. J. Econ. Entomol. 97: 1378-1383.

Curkovic, T., and J. E. Araya. 2004. Acaricidal action of two detergents against *Panonychus ulmi* (Koch) and *Panonychus citri* (McGregor) (Acarina: Tetranychidae) in the laboratory. Crop Prot. 23: 731-733.

Duso, C., F. Chiarini, L. Conte, V. Bonora, L. Dalla Montà, and S. Otto. 2004. Fogging can control *Tetranychus urticae* on greenhouse cucumbers. J. Pest. Sci. 77: 105-111.

Fei, W. C., and Y. M. Wang. 2004. Plant Protection Manual. Taiwan Agricultural Chemicals and Toxic Substances Research Institute, Council of Agriculture, Executive Yuan, Taichung, Taiwan. 835 pp. (in Chinese)

Ginsburg, J. M. 1935. New wetting agents for old insecticides. J. Econ. Entomol. 28: 224-228.

Helle, W., and M. W. Sabelis. 1985. Spider Mites: Their Biology, Natural Enemies and Control, vol. 1 part B. Elsevier, Amsterdam. 458 pp.

Ho, C. C. 1988. An introduction to the exotic mite pests in Taiwan. Chinese J. Entomol. Special Publ. 2: 155-166. (in Chinese)

Ho, C. C. 2000. Spider-mite problems and control in Taiwan. Exp. Appl. Acarol. 24: 453-462.

Ho, C. C., K. C. Lo, and W. H. Chen. 1995. Spider mites injurious to economic plants in Taiwan and the toxicity of twelve acaricides to two major species (Tetranychidae; Acari). J. Agric. Res. China 44: 157-165. (in Chinese)

Imai, T., S. Tsuchiya, and T. Fujimori. 1995. Humidity effects on activity of insecticidal soap for the green peach aphid, *Myzus persicae* (Sulzer) (Hemiptera: Aphididae). Appl. Entomol. Zool. 30: 185-188.

Imai, T., S. Tsuchiya, and T. Fujimori. 1997. Effect of water hardness on the activity of insecticidal soap for the green peach aphid, *Myzus persicae* (Sulzer) (Hemiptera: Aphididae). Appl. Entomol. Zool. 32: 245-246.

Kaya, H. K., T. M. Burlando, H. Y. Choo, and G. S. Thurston. 1995. Integration of entomopathogenic nematodes with *Bacillus thuringiensis* or pesticidal soap for control of insect pests. Biol. Contr. 5: 432-441.

Lee, W. T., and K. C. Lo. 1989. Integrated control of two-spotted spider mite on strawberry in Taiwan. Chinese J. Entomol. Special Publ. 3: 125-137. (in Chinese)

Lo, K. C., and C. N. Chen. 1995. Recent progress in the biological control of crop pests in Taiwan. Plant Prot. Bull. 37: 357-380. (in Chinese)

Lo, K. C., H. K. Tseng, and C. C. Ho. 1984. Biological control of spider mites on strawberry in Taiwan (I). J. Agric. Res. China 33: 406-417. (in Chinese)

Lo, K. C., W. J. Wang, and D. S. Liu. 1993. The mite pests on floricultural crops and their control in Taiwan. Plant Prot. Bull. 35: 191-203. (in Chinese)

Lu, C. T., and C. L. Wang. 2005. An investigation of spider mites on papaya and reevaluation of some acaricides. Plant Prot. Bull. 47: 273-279. (in Chinese)

Moore, W. S., J. C. Profita, and C. S. Koehler. 1979. Soaps for home landscape insect control. Calif. Agric. 33: 13-14.

Osborne, L. S. 1982. Is soap a viable method for controlling *Tetranychus urticae* on plants in the interior environment? Proc. Fla. State Hort. Soc. 95: 149-151.

Osborne, L. S. 1984. Soap spray: an alternative to a conventional acaricide for controlling the twospotted spider mite (Acari: Tetranychidae) in greenhouses. J. Econ. Entomol. 77: 734-737.

Osborne, L. S., and F. L. Petitt. 1985. Insecticidal soap and the predatory mite, *Phytoseiulus persimilis* (Acari:

Phytoseiidae), used in management of the twospotted spider mite (Acari: Tetranychidae) on greenhouse grown foliage plants. J. Econ. Entomol. 78: 687-691.

Pinnock, D. E., R. J. Brand, J. E. Milstead, and N. F. Coe. 1974. Suppression of population of *Aphis gossypii* and *A. spiraecola* by soap sprays. J. Econ. Entomol. 67: 783-784.

Puterka, G. J., W. Farone, T. Palmer, and A. Barrington. 2003. Structure-function relationships affecting the insecticidal and miticidal activity of sugar esters. J. Econ. Entomol. 96: 636-644.

Shih, C. I. T. 2001. Automatic mass-rearing of *Amblyseius womersleyi* (Acari: Phytoseiidae). Exp. Appl. Acarol. 25: 425-440.

Smith, S. F., and V. A. Krischik. 2000. Effects of biorational pesticides on four coccinellid species (Coleoptera: Coccinellidae) having potential as biological control agents in interiorscapes. J. Econ. Entomol. 93: 732-736.

SPSS. 1999. User's Manual, Version 10.0. SPSS, Chicago, IL.

Stewart, C. D., S. K. Braman, B. L. Sparks, J. L. Williams-Woodward, G. L. Wade, and J. G. Latimer. 2002. Comparing an IPM pilot program to a traditional cover spray program in commercial landscapes. J. Econ. Entomol. 95: 789-796.

Tulisalo, U. 1974. Control of the two-spotted spider mite (*Tetranychus urticae* Koch) by high air humidity or direct contact with water. Ann. Entomol. Fenn. 40: 158-162.

Wang, W. J., and D. S. Liu. 1996. Effect of non-pesticidal substances against two-spotted spider mites on roses. Bull. Taichung District Agric. Improvement Station 50: 21-28. (in Chinese)

Ware, G. W., and D. M. Whitacre. 2004. The Pesticide Book. 6th edition. MeisterPro Information Resources, Willoughby, OH. 487 pp.

Zhang, Z. Q., and J. P. Sanderson. 1990. Relative toxicity of abamectin to the predatory mite *Phytoseiulus persimilis* (Acari: Phytoseiidae) and twospotted spider mite (Acari: Tetranychidae). J. Econ. Entomol. 83: 1783-1790.

Received: March 13, 2006
Accepted: April 7, 2006

皂液對二點葉蟎（*Tetranychus urticae* Koch）(蟎蜱亞綱：葉蟎科）致死效果評估

李啓陽* 羅幹成 姚美吉 行政院農業委員會農業試驗所應用動物組 台中縣 413 霧峰鄉中正路 189 號

彭武康 吳文哲 國立台灣大學昆蟲學系 台北市 106 大安區羅斯福路四段 113 巷 27 號

摘 要

本文報導皂液對二點葉蟎的致死影響研究。選取七種市售家用肥皂加水稀釋成皂液，在實驗室內使用葉浸法對二點葉蟎雌成蟎及卵粒進行觸殺及殘毒生物檢定，評估皂液對葉蟎的致死影響。結果顯示雌成蟎浸泡於不同皂液(4 g/l) 1～8 秒，處理時間之死亡率為 93.1～98.6%差異不顯著，與浸泡於對照藥劑阿巴汀(0.01 g (AI)/l)的死亡率(100%)亦無顯著差異。卵粒分別浸泡皂液與蒸餾水後之孵化率差異不顯著，孵化後若蟎再次浸泡皂液之死亡率為 89.2～98.8%，故亦無法完全將若蟎殺除。雌成蟎經由肥皂殘毒生物檢定，結果顯示肥皂殘毒試驗的雌成蟎與用蒸餾水試驗的死亡率無顯著差異。皂液中之二價金屬離子濃度亦會影響對二點葉蟎的殺蟎效果，將雌成蟎浸泡於以標準硬水為溶劑的肥皂水溶液，其死亡率皆低於浸泡於以蒸餾水為溶劑的皂液，且差異顯著。

關鍵詞：二點葉蟎、家用肥皂、皂液、生物檢定、標準硬水。

*論文聯繫人
e-mail: cylee@wufeng.tari.gov.tw