Insecticidal Activities of Aromatic Plant Extracts against Four Agricultural Insects

Soon-Il Kim, Ook-Kyun Shin[1], Cheol Song[1], Kwang-Yun Cho[1] and Young-Joon Ahn*

School of Agricultural Biotechnology, Seoul National University, Suwon 441-744,
[1]Korea Research Institute of Chemical Technology, Yusung 305-600, Korea

Received February 8, 2001

The insecticidal activities of 30 aromatic plant extracts against four insect pests were examined by direct contact application. Against *Nilaparvata lugens* female adults, *Myzus persicae* female adults, and *Plutella xylostella* larvae, at 5,000 ppm, >90% mortality was achieved in the methanol extracts of the rhizomes from *Cnidium officinale*, *Acorus gramineus*, *Acorus calamus* var. *angustatus* and *Curcuma longa*, the whole plant from *Agastache rugosa*, the fruits from *Illicium verum* and *Piper nigrum*, and the flower bud from *Eugenia caryophyllata* as well as *Cinnamomum camphora* steam distillate. Against *Spodoptera litura* larvae, all test plant extracts were ineffective. The plants described merit further study as potential insect-control agents against insect pests.

Key words: *natural insecticide, aromatic plant,* Curcuma longa, Cinnamomum camphora, Illicium verum, Piper nigrum.

Over several decades, various attempts to control insect pests have taken an effort toward effective eradication or prevention through the development of synthetic insecticides. Although effective, their repeated use has disrupted natural biological control systems and led to outbreaks of insect pests, sometimes resulted in the widespread development of resistance, had undesirable effects on non-target organisms, and fostered environmental and human health concerns.[1-3] These problems have highlighted the need for the strategies of selective control.

Plants may be an alternative source of currently used insect-control agents because they constitute a rich source of bioactive compounds and many of them are largely free from harmful adverse effects. Much effort has, therefore, been focused on plant-derived materials as potential sources of commercial insect-control agents or as lead compounds.[4-7] Little work has been done to manage insect pests or their damage by using aromatic plants despite their excellent pharmacological actions.[8,9]

In the laboratory study described herein, we assessed the insecticidal activities of the methanol extracts from 29 aromatic plant species and a steam distillate against four economically important agricultural insect pests (*Nilaparvata lugens* Stål, *Myzus persicae* Sulzer, *Plutella xylostella* L., and *Spodoptera litura* F.) using direct contact application.

*Corresponding author
Phone: 82-331-290-2462; Fax: 82-331-296-1650
E-mail: yjahn@snu.ac.kr

Abbreviations: RH, relative humidity.

Materials and Methods

Insects. The susceptible strains of *N. lugens*, *M. persicae*, and *P. xylostella* had been maintained in the laboratory without exposure to any insecticide on rice plant (*Oryza sativa* L.) seedlings (7-10 days after germination), tobacco plant (*Nicotiana tabacum* L.), and chinese radish (*Raphanus sativus* L.) seedlings (5-6 days after germination) in acrylic cages at 25 ± 1°C and 40-60% RH under a photoregime of 16 : 8 (L : D) h, respectively. *S. litura* was laboratory reared on artificial diet in plastic containers (28 × 20 × 9 cm) as previously described.[10]

Plant materials and sample preparation. A total of 30 aromatic medicinal plant species were purchased from Boeun medicinal herb shop, Kyungdong Market, Seoul, Korea (Table 1). With the exception of *Chaenomeles sinensis* and *Cinnamomum camphora*, the plants were dried in an oven at 40°C for 2 days and finely powdered using a blender. Each sample (50 g) was extracted twice with methanol (300 m*l*) at room temperature for 2 days and filtered. Slices (200 g) of the fresh *Chaenomeles* fruits were ground in a blender, extracted twice with methanol (900 m*l*) at room temperature for 1 day, and filtered. The combined filtrate was concentrated to dryness by rotary evaporation at 40°C. The yield of each methanol extraction is given in Table 1. *C. camphora* was purchased as a steam distillate.

Bioassay. The plant materials were tested at concentrations of 2,500 and 5,000 ppm by direct contact application. Each test material (dissolved in 4 m*l* acetone) was suspended in distilled water (36 m*l*) with Triton X-100 (Coseal, Seoul) added at a rate of 0.1 m*l*/liter. Controls received acetone-Triton X-100 solution.

Table 1. Aromatic medicinal plants tested.

Plant name	Family name	Tissue sampled[a]	Yield (%)[c]
Angerica dahurica	Apiaceae	Ro	17.7
Cnidium officinale	Apiaceae	Rh	10.0
Foeniculum vulgare	Apiaceae	Fr	4.9
Acorus calamus var. angustatus	Araceae	Rh	10.1
Acorus gramineus	Araceae	Rh	9.5
Artemisia princeps var. orientalis	Compositae	Wp	6.6
Inula helenium	Compositae	Ro	16.3
Dioscorea batatas	Dioscoreaceae	Rh	2.4
Gleditsia horrida	Fabaceae	Fr	17.3
Glycyrrhiza glabra	Fabaceae	Ro	21.9
Agastache rugosa	Labiatae	Wp	9.5
Schizonepeta tenuifolia	Labiatae	Wp	8.1
Thymus mandschuricus	Labiatae	Wp	28.0
Cinnamomum camphora	Lauraceae	-[b]	-
Cinnamomum cassia	Lauraceae	Ba	5.1
Illicium verum	Magnoliaeceae	Fr	26.1
Magnolia obovata	Magnoliaeceae	Ba	5.8
Eugenia caryophyllata	Myrtaceae	Fb	37.8
Paeonia suffruticosa	Paeoniaceae	Rb	18.6
Piper nigrum	Piperaceae	Fr	10.1
Rheum coreanum	Polygonaceae	Rh	41.6
Lysimachia davurica	Primulaceae	Wp	9.0
Chaenomeles sinensis	Rosaceae	Fr	60.8
Evodia rutaecarpa	Rutaceae	Fr	9.5
Zanthoxylum piperitum	Rutaceae	Fr	20.7
Zanthoxylum schinifolium	Rutaceae	Fr	16.2
Stemona japonica	Stemonaceae	Ro	15.2
Aquillaria agallocha	Thymelaeaceae	Li	6.6
Nardostachys chinensis	Valerianaceae	Rh	12.9
Curcuma longa	Zingiberaceae	Rh	11.1

[a]Ba, bark; Fb, flower bud; Fr, fruit; Li, lignin; Rb, root bark; Rh, rhizome; Ro, root; and Wp, whole plant.
[b]Steam distillate.
[c]The other plants, (dry weight of methanol extract/50 g of dry weight of test plant) ×100; and *Chaenomeles sinensis*, (dry weight of methanol extract/200 g of fresh weight of fruit) ×100.

Spray method was used for the bioassay of *N. lugens*. Ten female adults (3- to 5-day-old) were transferred onto a test tube (3 × 15 cm) containing five rice plant seedlings (7-10 days after germination) wrapped with cotton and water (10 m*l*). Each solution of test materials was applied at a rate of 0.1 m*l* per test tube by a glass spray unit connected to a forced air supply (Pacific Chemical, Seoul).

The toxicity of test materials to *P. xylostella* larvae (2nd instar), *S. litura* larvae (3rd instar), and *M. persicae* female adults was examined by leaf dipping assay. Cabbage (*Brassica oleracea* L., 25-day-old) leaves for larvae of *P. xylostella* and *S. litura*, and tobacco leaves for *M. persicae* females from each plant species grown in glasshouse were collected, and disks (5.5 diameter) were punched from each leaf. Leaf disks were dipped in each test solution (20 m*l*) for 30 s. After drying in a hood for 30 min, 10 individuals of *P. xylostella* larvae, *S. litura* larvae, and *M. persicae* females were placed separately onto the treated and the control leaf disks in petri dishes (6 × 1.5 cm).

Treated and control insects were held at 25 ± 1°C and 40-60% RH under a photoregime of 16 : 8 (L : D) h. Mortalities were determined 48 h after treatment. Test insects were considered dead if appendages did not move when prodded with a camel's hair brush. All treatments were replicated six or more times. No mortality was observed in each control.

Results and Discussion

The insecticidal activities of test materials against *N. lugens* females when used at 5,000 ppm are given in Table 2. Adulticidal activities (>90% mortality) were observed in the extracts of *Acorus calamus* var. *angustatus* rhizome, *Agastache rugosa* whole plant, *Eugenia caryophyllata* flower bud, *Piper nigrum* fruit, and *Curcuma longa* rhizome. *Acorus gramineus* rhi-

Table 2. Insecticidal activities of aromatic medicinal plant extracts against four insects, using direct contact application.[a]

Plant name[b]	Mortality (mean ± SE), %			
	N. lugens	*M. persicae*	*P. xylostella*	*S. litura*
A. dahurica	33.3 ± 7.3	0	0	0
C. officinale	69.3 ± 3.3	100	100	0
A. calamus var. angustatus	100	60.0 ± 5.8	96.7 ± 3.3	0
A. gramineus	80.0 ± 5.8	46.7 ± 6.7	91.7 ± 4.4	16.7 ± 3.3
A. princeps var. orientalis	0	0	0	5.0 ± 2.9
A. rugosa	100	0	0	0
C. camphora	81.7 ± 1.7	100	100	0
C. cassia	18.3 ± 4.4	0	0	0
I. verum	28.3 ± 6.0	96.7 ± 3.3	100	0
E. caryophyllata	91.7 ± 1.7	95.0 ± 5.0	35.0 ± 5.0	0
P. suffruticosa	30.0 ± 5.0	0	0	0
P. nigrum	98.3 ± 1.7	100	100	23.3 ± 3.3
Z. piperitum	50.0 ± 5.0	0	0	0
Z. schinifolium	30.0 ± 5.0	0	0	0
C. longa	96.7 ± 3.3	0	100	0

[a]Exposed to 5,000 ppm for 48 h.
[b]Plants having 0% mortality were not presented.

Table 3. Insecticidal activities of selected test plant extracts against three insects, using direct contact application.

Plant name[a]	Mortality (meanSE), %[b]		
	N. lugens	*M. persicae*	*P. xylostella*
C. officinale	0	0	0
A. calamus var. angustatus	76.7 ± 3.3	20.0 ± 0.0	66.7 ± 3.3
A. rugosa	8.3 ± 4.4	0	0
C. camphora	35.0 ± 7.6	100	100
I. verum	25.0 ± 8.7	86.7 ± 3.3	46.7 ± 8.8
E. caryophyllata	0	0	0
P. nigrum	0	0	96.7 ± 3.3
C. longa	96.7 ± 3.3	0	96.7 ± 3.3

[a]Of 30 medicinal plants used, plants having >90% mortality were selected.
[b]Exposed to 2,500 ppm for 48 h.

zome extract and *Cinnamomum camphora* steam distillate revealed 80.0 and 81.7% mortality, respectively. The other 23 plant extracts exhibited weak or no insecticidal activity.

The effects of test materials on the toxicity of *M. persicae* females were determined by leaf dipping assay (Table 2). Aphicidal activities (>90% mortality) were achieved in the extracts of *Cnidium officinale* rhizome, *Illicium verum* fruit, *E. caryophyllata* flower bud, and *P. nigrum* fruit as well as *C. camphora* steam distillate.

Significant differences were obtained in the toxicity to two lepidopteran larvae used (Table 2). Larvicidal activities (>90% mortality) against *P. xylostella* were produced from the extracts of *C. officinale* rhizome, *A. calamus* var. *angustatus* rhizome, *A. gramineus* rhizome, *I. verum* fruit, *P. nigrum* fruit, and *C. longa* rhizome as well as *C. camphora* steam distillate. However, all test plant materials were ineffective against *S. litura* larvae.

Of the 30 plants used, the insecticidal activities of nine plants having >90% mortality were examined at 2,500 ppm by direct contact application (Table 3). *C. longa* rhizome extract exhibited 96.7% mortality against *N. lugens* females and *P. xylostella* larvae. The insecticidal activity (100% mortality) against *M. persicae* females and *P. xylostella* larvae was obtained in *C. camphora* steam distillate. The fruit extracts of *I. verum* and *P. nigrum* gave 86.7 and 96.7% mortality against *M. persicae* females and *P. xylostella* larvae, respectively.

It has been well recognized that many plant extracts or phytochemicals could be developed into products suitable for integrated pest management because many of them are selective to pests, have no or little harmful effects on non-target organisms and the environment, act in many ways on various types of pest complex, and may be applied to the plant in the same way as other agricultural chemicals.[4-7,11] Jacobson[12] has pointed out that the most promising botanical insect-control agents are in the families Annonaceae, Asteraceae, Canellaceae, Labiatae, Meliaceae, and Rutaceae. Derivatives of

neem (*Azadirachta indica* A. Juss), belonging to the family Meliaceae, have a variety of biological activities against nearly 200 species of insects without any adverse effects on most non-target organisms.[13,14]

In our present study, responses varied with insect and plant species used. The insecticidal activities against *N. lugens* females, *M. persicae* females, and *P. xylostella* larvae were obtained in the methanol extracts of the rhizomes from *C. officinale*, *A. calamus* var. *angustatus*, *A. gramineus* and *C. longa*, the whole plant from *A. rugosa*, the fruits from *I. verum* and *P. nigrum*, and the flower bud of *E. caryophillata* as well as *C. camphora* steam distillate. These plant species confirm their usefulness as insect-control agents. The insecticidal activities were noted in *C. camphora* extract against *Callosobruchus* spp.,[15] *I. verum* fruit extract against *Blattella germanica* (L.), *Culex pipiens pallens* (Coquillett) and *Musca domestica* (L.),[16] eggs, larvae and adults of *Tribolium castaneum* (Herbst) and adults of *Sitophilus zeamais* (Motsch.),[17] and *A. calamus* essential oil against some stored-product insects.[18]

In conclusion, derivatives of test plants described could be useful for managing insect populations on crops, although their effects on natural enemies, crop qualities, or environment have not yet to be elucidated.

Acknowledgments. This work was supported by grants from the Ministry of Education (Brain Korea 21 Project) and the Ministry of Agriculture and Forestry through the R&D Promotion Center for Agriculture, Forestry and Fishery to YJA.

References

1. Brown, A. W. A. (1978) In *Ecology of Pesticides*. Wiley, New York.
2. Georghiou, G. P and Saito, Y. (1983) In *Pest Resistance to Pesticides*. Plenum, New York.
3. Hayes, J. B. Jr. and Laws, E. R. Jr. (1991) In *Handbook of Pesticide Toxicology*, Vol. **1**., Academic Press.
4. Jacobson, M. and Crosby, D. G. (1971) In *Naturally Occurring Insecticides*. Marcel Dekker, New York.
5. Arnason, J. T., Philogéne, B. J. R. and Morand, P. (1989) In *Insecticides of Plant Origin*. ACS Symp. Ser. No. **387**, Am. Chem. Soc., Washington, D.C.
6. Isman, M. B. (1995) Leads and prospects for the development of new botanical insecticides. *Rev. Pestic. Toxicol.* **3**, 1-20.
7. Hedin, P. A., Hollingworth, R. M., Masler, E. P., Miyamoto, J. and Thompson, D. G. (1997) In *Phytochemicals for Pest Control*. ACS Symp. Ser. No. **658**, Am. Chem. Soc., Washington, D. C.
8. Tang, W. and Eisenbrand, G. (1992) In *Chinese Drug of Plant Origin*. Springer-Verlag.
9. Namba, T. (1993) In *The Encyclopedia of Wakan-Yaku (Traditional Sino-Japanese Medicines) with Color Pictures*. Hoikusha, Osaka.
10. Im, D. J., Park, B. S., Jin, B. R., Choi, K. M., and Kang, S. K. (1988) Pathogenicity of nuclear polyhedrosis virus isolated from the tobacco cutworm, *Spodoptera litura*. *Korean J. Appl. Entomol.* **27**, 219-224.
11. Schmutterer, H. (1992) Control of diamondback moth by application of neem extracts. In *Diamondback Moth and Other Crucifer Pests*, Talekar, N. S. (ed), pp. 325-332, Proceedings of the Second International Workshop. AVRDC Publication, Tainan, Taiwan.
12. Jacobson, M. (1989) Botanical pesticides: past, present, and future. In *Insecticides of Plant Origin*, Arnason, J. T., Philogéne, B. J. R. and Morand, P (eds), pp. 1-10, ACS Symp. Ser. No. **387**. Am. Chem. Soc. Washington, D.C.
13. Saxena, R. C. (1989) Insecticides from neem. In *Insecticides of Plant Origin*, Arnason, J. T., Philogéne, B. J. R. and Morand, P (eds), pp. 110-135, ACS Symp. Ser. No. **387**. Am. Chem. Soc. Washington, D.C.
14. Lowery, D. T. and Isman, M. B. (1995) Toxicity of neem to natural enemies of aphids. *Phytoparasitica* **23**, 297-306.
15. Rajapakse, R. and van Emden, H. F. (1997) Potential of four vegetable oils and ten botanical powders for reducing infestation of cowpeas by *Callosobruchus maculatus*, *C. chinensis* and *C. rhodesianus*. *J. Stored Prod. Res.* **33**, 59-68.
16. Chang, K. S. (2001) Insecticidal activity of phenylpropene *trans*-anethole identified in *Illicium verum* fruit against three medical insect pests, MS thesis, Seoul National University, Suwon, Korea.
17. Ho, S. H., Ma, Y., Goh, P. M. and Sim, K. Y. (1995) Star anise, *Illicium verum* Hook. F. as a potential grain protectant against *Tribolium castaneum* (Herbst) and *Sitophilus zeamais* Motsch. *Postharvest Biol. Technol.* **6**, 341-347.
18. El-Nahal, A. K. M., Schmidt, G. H. and Risha, E. M. (1989) Vapours of *Acorus calamus* oil-a space treatment for stored-product insects. *J. Stored Prod. Res.* **25**, 211-216.