韓應昆誌 33(4) : 225~229 (1994)
Korean J. Appl. Entomol.

Larvicidal and Antifeeding Activities of Oriental Medicinal Plant Extracts against *Plutella xylostella* (Lepidoptera: Yponomeutoidae) and *Spodoptera litura* (Lepidoptera: Noctuidae)

배추좀나방과 담배거세미나방 유충에 대한 한방식물체의 살충활성 및 섭식저해활성

Jeong Hyun Kweon, Young Joon Ahn, Hyung Wook Kwon, Kyung Soo Jang[1] and Kwang Yun Cho[1]

권정현 · 안용준 · 권형욱 · 장경수[1] · 조광연[1]

ABSTRACT The methanol extracts from 30 species of oriental medicinal plants belonging to 24 families were tested for their larvicidal and antifeeding activities against diamondback moth (*Plutella xylostella* L.) and tobacco cutworm (*Spodoptera litura* F.) by a leaf-dipping method at a concentration of 5,000 ppm. The methanol extract from *Copti chinensis* only showed a potent larvicidal activity against *P. xylostella*. Strong antifeeding activity against *P. xylostella* was observed from the extracts from *Platycodon grandiflorum*, *Codonopsis pilosula*, *Asarum sieboldii*, Rhus chinensis and *Lithospermum erythrorhizon* And a potent antifeeding activity against *S. litura* was obtained from *Akebia quinata* and *Equisetum hyemale* extracts. A significant antifeeding activity against both species was obtained from *R. chinensis* and *C. chinensis* extracts.

KEY WORDS Screening, larvicidal activity, antifeeding activity, *Plutella xylostella*, *Spodoptera litura*, plant extract

초 록 배추좀나방과 담배거세미나방 유충에 대한 30종 한방식물체 메탄올 조추출물의 살충활성 및 섭식저해활성을 잎침지법을 이용하여 5,000 ppm으로 검정하였다. 황련의 추출물은 배추좀나방에 대해 살충작용을 보였다. 길경, 사삼, 세신, 오배자 및 자초의 추출물은 배추좀나방 유충에 대해, 목통 및 속새의 추출물은 담배거세미나방 유충에 대해 강한 섭식저해활성을 보였으나, 오배자와 황련의 추출물은 이들 나비목 유충 모두에 강한 섭식저해활성을 나타내었다.

검색어 스크리닝, 살유충활성, 섭식저해활성, 배추좀나방, 담배거세미나방, 식물추출물

The diamondback moth, *Plutella xylostella* (L.) and tobacco cutworm, *Spodoptera litura* (F.) are considered to be one of the most important insect pests of vegetables in the world. If not managed properly, these species could cause a serious yield loss with excessive feeding on the leaves by larvae. Control is primarily dependent on continued or repeated applications of insecticides. Although they have effectively controlled these insect pests, their extensive use for the past decades has disrupted control of these insect populations by natural enemies and has led to outbreaks of these insect pests, and the development of widespread resistance to various types of insecticides (Kim *et al.* 1990, Song 1992, Lee *et al.* 1993). Decreased efficacy and increasing concern over adverse effects of the earlier types of insecticides have brought about the need for the development of new types of selective alter-

Department of Agricultural Biology, College of Agriculture & Life Sciences, and Research Center for New-Biomaterials in Agriculture, Seoul National University, Suwon 441-744(서울대학교 농업생명과학대학 농생물학과 및 농업생물신소재연구센터)

[1]Korea Research Institute of Chemical Technology, Daejeon 305-606(한국화학연구소)

natives or methods of crop protection without, or with reduced use of organic insecticides.

Plants may be an alternative to currently used insect control agents, because they virtually are the richest source of bioactive organic chemicals (Harborne 1988). *Recently, much concern has been* focused on the distribution, nature, and practical use of chemical substances having the antifeeding activity for insects in plants. Antifeedants from plants have no or little harmful effects on non-target organisms and environment (Chapman 1974, Arnason *et al.* 1989, Schmutterer 1992), suggesting that they could be developed into products suitable for integrated pest management (IPM) in crops. In a previous paper (Kwon *et al.* 1994), we reported that potent antifeeding activity against larvae of both *P. xylostella* and *S. litura* was obtained from methanol extracts of eight oriental medicinal plant species including *Clerodendron trichotomum, C. trichotomum* var. *esculentum* and *Inura helenium*. Although oriental medicinal plants are rich source of organic chemicals (Namba 1986), little work has been done to manage insect populations or their damage by using them.

In the laboratory study described herein, we assessed the larvicidal and antifeeding activities against both *P. xylostella* and *S. litura* of methanol extracts of 30 species of oriental medicinal plants.

MATERIALS AND METHODS

Insects

Laboratory strains of the diamondback moth (*Plutella xylostella* L.) and tobacco cutworm (*Spodoptera litura* F.) were used for the experiments. They have been reared for several years without exposure to any insecticide in our laboratory by the same procedures described previously (Cho *et al.* 1988, Ahn & Cho 1992, Ahn *et al.* 1992).

Plants and Sample Preparation

Thirty oriental medicinal plant species belonging to 24 families are randomly or anecdotally selected and listed in Table 1. Fully expanded leaves from *Asarum sieboldii, Kochia scoparia* and *Epimedium koreanum* were collected during July to August 1992 from the Forestry Research Institute in Seoul. The other plant species were purchased from an oriental medicinal plant market in Seoul. These plant materials were dried in a blower at 60°C for 2 days, finely powdered using a blender, extracted twice with methanol at room temperature, and filtered (Toyo filter paper No. 2). The combined filtrate was concentrated in vacuo at 35°C, using rotary vacuum evaporator. The yield of each extraction is shown in Table 1.

Table 1. Plant species tested

Plant species	Family name	Part	Yield(%)
Beckmannia syzigachne	Gramineae	root	13
Imperata cylindrica		root	22
Platycodon grandiflorum	Campanulaceae	root	29
Codonopsis pilosula		root	6
Akebia quinata	Ladizabalaceae	stem	9
Equisetum hyemale	Equisetaceae	stem	5
Asarum sieboldii	Aristolochiaceae	leaf	13
Typha orientalis	Typaceae	pollen	10
Rhus chinensis	Anacardiaceae	gall	52
Lithospermum erythrorhizon	Borraginaceae	stem	28
Kochia scoparia	Chenopodiaceae	leaf	7
Gentiana scabra	Gentianaceae	root	29
Morus alba	Moraceae	root	3
Cynanchum wilfordii	Asdepiadaceae	root	11
Juncus effusus	Juncaceae	stem	3
Gastrodia elata	Orchidaceae	root	10
Bletilla striata		root	4
Rheum undulatum	Polygonale	root	50
Pleuropterus multiflorus		root	14
Jeffersonia dubia	Berberidaceae	root	16
Epimedium koreanum		leaf	9
Copti chinensis	Ranunculaceae	root	21
Cuscuta japonica	Convolvulaceae	fruit	6
Euonymus japonaca	Celastraceae	fruit	7
Cercidiphyllum japonicum	Cercidiphyllaceae	skin	2
Megnolia kobus	Megnoliaceae	root	7
Liriope platyphylla	Liliaceae	root	13
Polygala tatarinow	Polygalaceae	root	24
Achyranthes japonica	Amaranthaceae	root	19
Anemarrhena asphodeloides	Haemodoraceae	root	16

Bioassay

Leaf-dipping method was used for larvicidal and antifeeding activities of test materials against *P. xylostella* and *S. litura* at a concentration of 5,000 ppm.

Test samples suspended in distilled water with Triton X-100 spreader (Dong Yang Chemical Co., Seoul) added at the rate of 0.1 ml/liter were used. Leaves of chinese cabbage (*Brassica oleracea* var. *capitata* L.) grown in green house were collected and disks (2 cm diameter) were punctured Three leaf disks were dipped in test solution for 30s. After evaporation in a hood for 2h. second-inster larvae of each *S litura* and *P. xylostella* were placed on the treated and control leaf disks in Petri dishes All treated materials were held in a room at 25± 1°C, 50~60% RH, and a photoperiod of 16 : 8 (L : D) h. All treatments were replicated three times.

Larvicidal activity was evaluated after 48h, and classified as follow· the strong activity + + +, mortality>80%; moderate + +, mortality 80~61%, weak +, mortality 60~40%, and no response −, mortality<40%. Antifeeding activity was calculated according to the method of Isman *et al.* (1990), evaluated after 24h, and classified as follow· the strong antifeeding activity + +. >80%, moderate +. 80~50%; and no activity −<50%

RESULTS

The most important factor in primary screening for bioactive substances may be the starting concentration. In our previous papers (Cho *et al.* 1987, Ahn & Cho 1992, Ahn *et al.* 1992), we reported that a concentration of 5,000~8,000 ppm of a plant extract did not cause any problems such as solubility and detection of its minor active components. Methanol extracts of 30 species of plants were subjected to a screening test for their larvicidal and antifeeding activities at a concentration of 5,000 ppm for *P. xylostella* and *S. litura*.

Larvicidal Activity

Among the plant species tested, the methanol extract of *Copti chinensis* (Family Ranunculaceae) roots only showed potent larvicidal activity (+ +) against *P. xylostella* (Table 2). The other 29 plant extracts were nontoxic to larvae of both species tested.

Antifeeding Activity

The antifeeding activity of test materials against larvae of *P. xylostella* and *S. litura* are quite variable in relative to both insect and plant species (Table 3). Of these 30 species of plants. the following five samples exhibited a strong antifeeding activity against *P xylostella larvae: P. grandiflorum* and *C. pilosula* (Family Campanulaceae), *A. sieboldii* (Family Aristolochiaceae), *R. chinensis* (Family Anacardiaceae) and *L. erythrorhizon* (Family Borraginaceae). Potent antifeeding activity against *S. litura* larvae was obtained from the extracts of *A. quinata* (Family Ladizabalaceae) and *E. hyemale* (Family Equisetaceae). The methanol extracts from *R. chinensis* (Fa-

Table 2. Larvicidal activity of methanol extracts against *Plutella xylostella* and *Spodoptera litura*[a]

Plant species	Larvicidal activity[b]	
	P. xylostella	*S litura*
B syzigachne	−	−
I cylindrica	−	−
P grandiflorum	−	−
C pilosula	−	−
A. quinata	−	−
E hyemale	−	−
A. sieboldii	−	−
T. orientalis	−	−
R. chinensis	−	−
L. erythrorhizon	−	−
K scoparia	−	−
G. scabra	−	−
M. alba	−	−
C. wilfordii	−	−
J. effusus	−	−
G elata	−	−
B. striata	−	−
R. undulatum	−	−
P. multiflorus	−	−
J. dubia	−	−
E. koreanum	−	−
C chinensis	+ +	−
C. japonica	−	−
E. japonaca	−	−
C. japonicum	−	−
M kobus	−	−
L. platyphylla	−	−
P tatarinow	−	−
A. japonica	−	−
A. asphodeloides	−	−

[a] 5,000 ppm treatment.
[b] + +: >80%, +: 80%~50%, −: <50%

Table 3. Antifeeding activity of methanol extracts against *Plutella xylostella* and *Spodoptera litura*[a]

Plant species	Antifeeding activity[b]	
	P. xylostella	*S. litura*
B. syzigachne	+	−
I. cylindrica	−	−
P. grandiflorum	++	−
C. pilosula	++	−
A. quinata	+	++
E. hyemale	−	++
A. sieboldii	++	+
T. orientalis	+	−
R. chinensis	++	++
L. erythrorhizon	++	+
K. scoparia	+	−
G. scabra	+	−
M. alba	+	−
C. wilfordii	−	−
J. effusus	−	−
G. elata	−	−
B. striata	+	−
R. undulatum	+	−
P. multiflorus	−	−
J. dubia	++	+
E. koreanum	−	+
C. chinensis	++	++
C. japonica	+	−
E. japonaca	−	−
C. japonicum	−	+
M. kobus	+	+
L. platyphylla	−	+
P. tatarinow	−	−
L. japonica	+	−
A. asphodeloides	+	+

[a] 5,000 ppm treatment.
[b] ++: >80%, +: 80%~50%, −: <50%

mily Berberidaceae) and *C. chinensis* showed a significant antifeeding activity against both species.

DISCUSSION

In the laboratory study with larvae of *P. xylostella* and *S. litura*, antifeeding activity was both plant and insect species dependent. The plants belonging to the families Anacardiaceae, Aristolochiaceae, Ladizabalaceae, Borraginaceae, Berberidaceae, and Ranunculaceae showed a strong antifeeding activity against both insect species, whereas the extract of roots from *C. chinensis* belonging to the family Ranunculaceae showed both insecticidal and antifeeding activities against *P. xylostella* larvae. Jacobson (1989) pointed out that the most promising botanicals as sources of novel plant-based insecticides for use at the present time and in the future are species of the families Meliaceae, Rutaceae, Asteraceae, Annonaceae, Labiatae, and Canellaceae. However, Kwon *et al.* (1994) reported that the plants belonging to the families Verbenaceae, Compositae, and Umbelliferae revealed a potent antifeeding activity against both *P. xylostella* and *S. litura* larvae.

Certain plant-derived extracts and phytochemicals can not only be useful as insecticides, but also reduce plant damage below the economic injury level. They are being considered as potential alternatives for organic insecticides (Jacobson & Crosby 1971, Arnason *et al.* 1989). Derivatives of neem (*Azadirachta indica* A. Juss) belonging to the family Meliaceae are found to have a variety of biological activities against nearly 200 species of insects without any adverse effects on non-target organisms (Saxena 1989, Schmutterer 1992). It is well recognized that the use of antifeedants is of considerable potential value in crop protection, based upon the fact that they have selectivity towards the natural enemies, and may be applied to the plant in the same way as other agricultural chemicals (Munakata 1970, Chapman 1974).

Extracts from neem seed/neem seed kernels have shown a great potential for IPM in controlling *P. xylostella* in cabbage and related vegetables owing to their selectivity, although their application in cabbage can have a change of plant color and reduction of headsize (Schmutterer 1992). Plant-derived extracts are found to be only effective against insects for a relatively short period of time. However, extracts from neem seeds gave good protection of crops against *P. xylostella* for 6 days (Schmutterer 1992), and against swarms of Schistocerca gregaria for up to 2 wk if it was not washed off by rain (Pradhan & Jotwani 1968). However, little information is available for antifeeding activity of oriental medicinal plants, although these plants have long been considered to have natural properties. In our study, the methanol extracts of *R. chinensis* and *C. chinensis* showed a strong antifeeding activity against larvae of both *P. xylostella* and *S. litura*

Based on present results and these earlier findings, antifeedants extracted from oriental medicinal plants might be a useful material for developing new types of biorational management agents for controlling both *P. xylostella* and *S. litura* populations, although their effects on natural enemies, vegetable qualities, or environment has not been fully investigated.

Further work to identify the biologically active substances from *R. chinensis* and *C. chinensis* which show the most potent antifeeding activity is in progress.

ACKNOWLEDGEMENTS

This research was supported by grant 90-05-00-07 from the Korea Science and Engineering Foundation to Y.J.A.

REFERENCES

Ahn, Y. J. & K. Y. Cho. 1992. Establishment of bioassay system for developing new insecticides I Effects of organic solvents on the toxicity against insects, phytotoxicity and solubility of compounds. *Korean J. Appl. Entomol.* **31**: 182-189.

Ahn, Y. J., K. H. Kim, N. J. Park & K. Y. Cho. 1992. Establishment of bioassay system for developing new insecticides II. Differences in susceptibilities of the insect species to insecticides according to different application methods. *Korean J. Appl. Entomol.* **31**: 452-460.

Arnason, J. T., B. J. R. Philogene & P. Morand. 1989. Insecticides of Plant Origin. ACS Symposium 387, *Amer. Chem. Soc.,* Washington, D.C

Chapman, R. F. 1974. The chemical inhibition of feeding by phytophagous insects: a review. Bull. Ent. Res. **64**: 339-363.

Cho, K. Y., J. W. Ahn & Y. J. Ahn. 1988. The Establishment of Screening System for Developing New Agrochemicals, The Ministry of Science, Seoul, Republic of Korea, 916 p.

Harbone, J. B. 1988. Introduction of Ecological Biochemistry. Academic Press.

Isman, M., B. O. Koul, A. Luczynski & J. Kaminski. 1990. Insecticidal and antifeedant bioactivities of neem oils and their relationship to azadirachtin content *J Agric. Food Chem.* **38**: 1406-1411.

Jacobson, M. 1989. Botanical pesticides-past, present, and future, pp. 1-10 In Insecticides of Plant Origin, ed by J. T. Arnason, B. J. R. Philogene & P Morand ACS Symposium 387. *Amer. Chem. Soc.*, Washington, D.C

Jacobson, M. & D. G. Crosby. 1971. Naturally Occurring Insecticides. Marcel Decker, New York

Kim, G. H., Y. S. Suh, J. H. Lee & K. Y. Cho 1990. Development of fenvalerate resistance in the diamondback moth, *Plutella xylostella* Linne (Lepidoptera: Yponomeutidae). *Korean J. Appl Entomol* **29**: 194-200.

Kwon, H. W., Y. J. Ahn, J. H. Kwon, S. G. Lee & B. H. Byun. 1995. Larvicidal and antifeeding activities of oriental medicinal plant extracts against *Plutella xylostella* (Lepidoptera: Yponomeutoidae.) and *Spodoptera litura* (Lepidoptera: Noctuidae). Agricultural Chemistry and Biotechnology (in press)

Lee, S. C., Y. S. Cho & D. I. Kim. 1993. Comparative study of toxicological methods and field resistance to insecticides in diamondback moth (Lepidoptera: Plutellidae). *Korean J. Appl. Entomol.* **32**: 323-329.

Munakata, K 1970. Insect antifeedants in plants, pp. 179-187 In Control of Insect Behaviour by Natural Products, ed. by D. L. Wood, R. M. Nakajima Academic Press, New York.

Namba, T. 1986. Colored Illustrations of Wakan-Yaku (the Crude Drugs in Japan, China and the Neighbouring Countries). Hoikusha Publishing Co., Osaka, Japan.

Pradhan, S. & M. G. Jotwani. 1968. Neem as an insect deterrent. *Chem. Age India* **19**: 756-760.

Saxena, R. C. 1989. Insecticides from neem, pp. 110-135. *In* Insecticides of Plant Origin, ed. by J T. Arnason, B. J. R. Philogene & P Morand. ACS Symposium 387. *Amer. Chem. Soc.*, Washington, D.C.

Schmutterer, H. 1992. Control of diamondback moth by application of neem extracts, pp. 325-332 In Diamondback Moth and Other Crucifer Pests. ed. by N. S. Talekar (ed.), Proceedings of the second international workshop, Tainan, Taiwan.

Song, S. S. 1992. Resistance of diamondback moth (*Plutella xylostella* L.) against the pyrethroids. *Korean J. Appl. Entomol.* **31**: 338-344.

(Received April 14, 1994)