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Larvicidal and Antifeeding Activities of Oriental Medicinal Plant Extracts against *Plutella xylostella* and *Spodoptera litura*

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Abstract: Methanol extracts from 45 species of oriental medicinal plants belonging to 17 families were subjected to a screening test for their larvicidal and antifeeding activities against two species of lepidopteran larvae, diamondback moth (*Plutella xylostella* L.) and tobacco cutworm (*Spodoptera litura* F.) by a leaf-dipping method. At a concentration of 8,000 ppm, methanol extract of *Corydalis turrschaninovii* roots only was found to have potent larvicidal activity against *S. litura.* At 5,000 ppm, strong antifeeding activity against both larvae was observed from the extracts of *Clerodendron trichotomum, C. trichotomum* var. *esculentum, Inura helenium, Arctium lappa, Artemisia messerschmidtiana, Anthriscus sylvestris, Angelica dahurica,* and *C. turrschaninovii* (Received October 22, 1994; accepted November 11, 1994).

Introduction

Among 296 species of the insect and mite pests of vegetables in the Republic of Korea, the most important of which are diamondback moth, *Plutella xylostella* (L.) and tobacco cutworm, *Spodoptera litura* (F.).[1,2] If not managed properly, these species cause serious yield losses when larvae excessively feed on the developing vegetables. Control is primarily dependent upon 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.[3-5] Decreased efficacy and increasing concern over adverse effects of the earlier types of insecticide have brought about the need for the development of new types of selective alternatives or of 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 rich source of bioactive organic chemicals. 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,[6-8] suggesting that they could be developed into products suitable for integrated pest management (IPM) in crops. Although oriental medicinal plants are rich source of organic chemicals,[9] little work has been done to manage insect populations or their damage by using them.

Key words: Larvicidal activity, antifeeding activity, *Plutella xylostella, Spodoptera litura,* plant extract
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In the laboratory study described herein, we assessed the larvicidal and antifeeding activities against both *P. xylostella* and *S. litura* of methanol extract of 45 species of oriental medicinal plants belonging to 17 families. Among the plants tested, the antifeeding components of *Clerodendron trichotomum* var. *esculentum*, the only *Clerodendron* species in southern coastal region of the Republic of Korea, has been investigated and will be reported elsewhere.

Materials and Methods

Insects

Laboratory strains of two insect species were used in this study: diamondback moth (*Plutella xylostella* L.) and tobacco cutworm (*Spodoptera litura* F.). They have been reared for several years without exposure to any insecticide in our laboratory by the same procedures described previously.[10-12]

Plants and sample preparation

The 45 oriental medicinal plant species belonging to 17 families are anecdotally selected and listed in Table 1. Fully developed leaves from *Clerodendron trichotomum*, *C. trichotomum* var. *esculentum*, *Symplocos chinensis* and *S. coreana* were collected during July to August 1992 at the Forestry Research Institute, Seoul, Republic of Korea. The other plant species were purchased from an oriental medicinal plant market in Seoul. These plant materials were dried in a blower at 60℃ for 3 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℃, using rotary vacuum evaporator. The yield of each extraction is shown in Table 1.

Bioassay

The most important factor in primary screening for bioactive substances may be the starting concentration. In a preliminary test, a concentration of 5,000～8,000 ppm of a plant extract did not cause any problem such as solubility and detection of mi-

Table 1. Oriental medicinal plant species tested

Plant species	Family name	Part	Yield (%)[1]
Morus bombycis	Moraceae	leaf	15
Broussonetia kazinoki	Moraceae	leaf	19
Acer barbinerve	Aceraceae	leaf	23
Chionanthus retusa	Oleaceae	leaf	23
Abeliophyllum distichum	Oleaceae	leaf	25
Fraxinus rhynchophylla	Oleaceae	root	35
Clerodendron trichotomum	Verbenaceae	leaf	20
Clerodendron trichotomum var. *esculentum*	Verbenaceae	leaf *seed*	18 *4*
Symplocos chinensis	Symplocaceae	leaf	23
Symplocos coreana	Symplocaceae	leaf	19
Eucommia ulmoides	Eucommiaceae	leaf	11
Inura helenium	Compositae	root	11
Arctium lappa	Compositae	root	15
Artemisia messerschmidtiana	Compositae	stem	10
Atractylodes japonica	Compositae	root	8
Carthamus tinctorius	Compositae	flower	19
Leonurus sibiricus	Labiatae	leaf	20
Schizonepeta tenuifolia var. *japonica*	Labiatae	leaf	6
Acanthopanax sessiliflorus	Araliaceae	root	23
Aralia continentalis	Araliaceae	root	12
Panax ginseng	Araliaceae	root	10
Kalopanax pictus	Araliaceae	cortex	10
Aconitum carmichaeli	Ranunculaceae	root	16
Clematis florida	Ranunculaceae	root	19
Paeonia japonica	Ranunculaceae	root	10
Aconitum pseudo-laeve var. *erectum*	Ranunculaceae	root	13
Anthriscus sylvestris	Umbelliferae	root	21
Angelica dahurica	Umbelliferae	root	12
Bupleurum falcatum	Umbelliferae	root	15
Ledebouriella seseloides	Umbelliferae	root	17
Angelica gigas	Umbelliferae	root	12
Torilis japonica	Umbelliferae	seed	3
Citrus aurantium	Rutaceae	fruit	15
Poncitrus trifoliata	Rutaceae	fruit	32
Phellodendron amurense	Rutaceae	cortex	15
Gleditsia sinensis	Leguminosae	fruit	10
Pueraria thunbergiana	Leguminosae	root	21
Astragalas membranaceus	Leguminosae	root	10
Corydalis turrschaninovii	Fumariaceae	root	1
Chaenomeles sinensis	Rosaceae	fruit	37
Crategus maximowiczii	Rosaceae	fruit	39
Prunus persica	Rosaceae	seed	8
Cyperus rotundus	Cyperaceae	fruit	5
Scirpus fluviatilis	Cyperaceae	root	9
Belamacanda chinensis	Iridaceae	root	20

[1](Weight/100 g of dry weight of test material)×100

nor active components.

Leaf-dipping method was used for larvicidal and antifeeding activities of test materials against *P. xylostella* and *S. litura*. The plant extracts were tested at a concentration of 8,000 ppm for larvicidal activity and 5,000 ppm for antifeeding activity. Test samples suspended in distilled water with Triton X-100 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 30 sec. After evaporation in a hood for 2 hr, 10 second instars of each *S. litura* and *P. xylostella* were placed onto the treated and control leaf disks in Petri dishes. All treated materials were held in a room at 25± 1℃, 50~60% RH, and a photoperiod of 16 : 8 (light/dark) hr. All treatments were triplicated.

Larvicidal activity was evaluated after 48 hr, 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.*,[13] evaluated after 24 hr, and classified as follows: the strong antifeeding activity + +, >80%; moderate +, 80~50 %; and no activity −, <50%.

Table 2. Antifeeding activity of methanol extracts against larvae of *Plutella xylostella* (DBM) and *Spodoptera litura* (TCW) by a leaf-dipping method[1]

Plant species	Antifeeding activity[2]		Plant species	Antifeeding activity[2]	
	DBM	TCW		DBM	TCW
M. bombycis	−	−	*A. carmichaeli*	+	+
B. kazinoki	−	−	*C. florida*	+	−
A. barbinerve	+	+	*P. japonica*	−	+ +
C. retusa	−	−	*A. pseudo-laeve* var. *erectum*	+ +	−
A. distichum	+	−			
F. rhynchophylla	−	−	*A. sylvestris*	+ +	+ +
C. trichotomum	+ +	+ +	*A. dahurica*	+ +	+ +
C. trichotomum	+ +[3]	+ +	*B. falcatum*	+ +	−
var. *esculentum*	+ +[4]	+ +	*L. seseloides*	−	−
S. chinensis	+	+	*A. gigas*	+ +	−
S. coreana	−	+	*T. japonica*	+ +	−
E. ulmoides	+	+	*C. aurantium*	+ +	−
I. helenium	+ +	+ +	*P. trifoliata*	+ +	−
A. lappa	+ +	+ +	*P. amurense*	−	−
A. messerschmidtiana	+ +	+ +	*G. sinensis*	+ +	+
A. japonica	+ +	+	*P. thunbergiana*	+ +	+
C. tinctorius	+	+	*A. membranaceus*	−	−
L. sibiricus	+ +	+	*C. turrschaninovii*	+ +	+ +
S. tenuifolia var. *japonica*	+ +	−	*C. sinensis*	−	−
			C. maximowiczii	−	−
A. sessiliflorus	+ +	+	*P. persica*	−	−
A. continentalis	−	−	*C. rotundus*	−	−
P. ginseng	+ +	+	*S. fluviatilis*	−	−
K. pictus	−	−	*B. chinensis*	+ +	−

[1] 5,000 ppm treatment.
[2] + +, >%80%; +, 80~50%; −, <50%.
[3] Leaves.
[4] Seeds.

Results

Larvicidal activity

Among the plant species tested, the methanol extract of *C. turrschaninovii* (Family Fumariaceae) roots only showed potent larvicidal activity (+++) against *S. litura*. However, the yield of methanol extraction of this plant species was very low (1%). The other 44 plant extracts were nontoxic to the larvae of both *P. xylostella* and *S. litura*.

Antifeeding activity

The activity of test samples investigated against larvae of *P. xylostella* and *S. litura* was both insect and plant species dependent (Table 2). Of the 45 species of plants, the following eight samples exhibited a strong antifeeding activity against both lepidopteran larvae: *C. trichotomum* and *C. trichotomum* var. *esculentum* (Family Verbenaceae), *I. helenium*, *A. lappa* and *A. messerschmidtiana* (Family Compositae), *A. sylvestris* and *A. dahurica* (Umbelliferae), and *C. turrschaninovii* (Family Fumariaceae).

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 Verbenaceae, Compositae, and Umbelliferae showed a strong antifeeding activity against both insect species, whereas the methanol extract of roots of *C. turrschaninovii* belonging to the family Fumariaceae showed both insecticidal and antifeeding activities against *S. litura* larvae. Jacobson[14] 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.

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.[7,15] 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.[16] 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 of pests, and may be applied to the plant in the same way as other agricultural chemicals.[6,17] In addition, most *P. xylostella* larvae were killed in immature stages,[18] and the natural enemies were an important factor in larval mortality[19] so that antifeedants may play a large role to increase mortality of survived larvae without any adverse effect on natural enemies.

Extracts from neem seed/neem seed kernels have shown 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.[8] Plant-derived extracts are found to be only effective against insects for a relatively short period of time. However, extracts of neem seeds gave good protection of crops against *P. xylostella* for 6 days,[8] and against swarms of *Schistocerca gregaria* for up to 2 weeks if it was not washed off by rain.[19] However, little information is available for antifeeding activity of oriental medicinal plants, although these plants have long been considered to have natural properties.[9] In our study, the methanol extracts of *C. trichotomum*, *C. trichotomum* var. *esculentum*, *I. helenium*, *A. lappa*, *A. messerschmidtiana*, *A. sylvestris*, *A. dahurica* and *C. turrschaninovii* showed a strong antifeeding activity against larvae of both *P. xylostella* and *S. litura*.

Based upon our results and these earlier findings, antifeedants from oriental medicinal plants might be useful product 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.

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배추좀나방과 담배거세미나방 유충에 대한 한방식물체 추출물의 살충 및 섭식저해활성

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초록 : 17과 45종 한방 식물체 메탄올 추출물의 배추좀나방과 담배거세미나방 유충에 대한 살충활성 및 섭식저해활성을 잎침지법으로 조사하였다. 살충활성은 8,000 ppm에서 조사하였는바, 현호색 추출물만이 담배거세미나방 유충에 대해 강한 살충활성을 보였다. 섭식저해활성은 5,000 ppm에서 조사한 결과, 누리장나무, 거문누리장나무, 목향, 우방자, 인진, 전호, 백지 및 현호색 추출물이 강한 섭식저해활성을 나타내었다.