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Insecticidal and Acaricidal Activities of Plant Extracts

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Abstract: Extracts of 43 species of plants were tested for their insecticidal and acaricidal activities against six species of insect pests and one mite species. The methanol extract of *Ginkgo biloba* leaves selectively was found to have potent insecticidal activity against *Nilaparvata lugens* (Stål), whereas steam distillate of *Thujopsis dolabarata* var. *hondai* sawdust showed potent insecticidal activities with a broad spectrum. The methanol extract of *Pinus densiflora* leaves and steam distillate of *T. dolabrata* var. *hondai* sawdust exhibited potent activities against *Tetranychus urticae* (Koch) (Received October 2, 1994; accepted November 14, 1994).

Introduction

Over the past decades, various attempts to control insect pests have taken an effort towards an effective eradication or prevention through the development of synthetic organic insecticides. Although they have effectively controlled some insect pests, their continued or repeated use has led to outbreaks and resurgences of insect pests,[1] the development of widespread resistance to insecticides,[2] toxicity to nontarget organisms, and environmental problems.[3] 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 alternatives for controlling insect pests.

Because plants virtually are the richest source of bioactive organic chemicals,[4] in recent years much concern has been focused on plant materials for potentially useful products such as nicotine, pyrethrins and rotenoids as commercial insecticides[5,6] or as lead compounds for synthetic insecticides such as physostigmine,[7] lead compound of carbamates, produced by *Physostigmine venenosum,* and pyrethrin, lead compound of synthetic pyrethroids, produced by *Chrysanthemum cinerariaefolium.*[8]

In the laboratory study described herein, we assessed the insecticidal and acaricidal activities of methanol extracts of 43 plant species in 32 families against six species of insect pests and one mite species. Among the plants tested, the methanol extract of *Ginkgo biloba* leaves selectively showed potent insecticidal activity against *Nilaparvata lugens* which is the most important rice insect pest.

Materials and Methods

Test organisms

Laboratory strains of seven species of pests were used in this study: brown planthopper (*Nilaparvata lugens* Stål), diamondback moth (*Plutella xylostella* L.), tobacco cutworm (*Spodoptera litura* Fab.), green

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peach aphid (*Myzus persicae* Sulzer), rice weevil (*Sitophilus oryzae* L.), german cockroach (*Blatella germanica* L.), and two-spotted spider mite (*Tetranychus urticae* Koch). They have been reared for se-

Table 1. List of plant species tested

Plant species tested	Family name	Part sampled[1]	Yield(%)[2]
Cercidiphyllum japonicum	Cercidiphyllaceae	L	26.8
Pteridium aquilinum var. *latiusculum*	Polypodiaceae	L & S	21.9
Diospyros lotus	Ebenaceae	L	25.4
Tilia kiusiana	Tiliaceae	L	12.2
Campsis grandiflora	Bignoniaceae	L	25.8
Parthenocissus tricuspidata	Vitaceae	L	32.0
Wistaria floribunda	Leguminosae	L	26.4
Cercis chinensis	Leguminosae	L	23.3
Robinia pseudo-acacia	Leguminosae	L	17.4
Trifolium repens	Leguminosae	L	22.4
Lagerstroemia indica	Lythraceae	L	23.2
Salvia officinalis	Labiatae	L	20.8
Equisetum hyemale	Equisetaceae	L & S	15.0
Artemisia princeps var. *orientalis*	Compositae	L	15.2
Ginkgo biloba	Ginkgoaceae	L	30.0
Callicarpa japonica	Verbenaceae	L	16.0
Plantago asiatica	Plantaginaceae	L	19.9
Celtis sinensis	Ulmaceae	L	15.4
Pulsatilla koreana	Ranunculaceae	L	11.7
Juglans sinensis	Juglandaceae	L	22.2
Cucurbita moschata	Cucurbitaceae	L	24.0
Abies koreana	Pinaceae	L	28.5
Abies holophylla	Pinaceae	L	37.5
Pinus densiflora	Pinaceae	L	33.1
Cudrania tricuspidata	Moraceae	L	22.4
Pterostyrax hispida	Styracaceae	L	27.3
Styrax japonica	Styracaceae	L	30.1
Acer palmatum	Aceraceae	L	33.0
Acer ginnala	Aceraceae	L	24.2
Rosa rugosa	Rosaceae	L	26.1
Chaenomeles lagenaria	Rosaceae	L	28.7
Pourthiaea villosa var. *brunnea*	Rosaceae	L	23.2
Amaranthus mangostranus	Amaranthaceae	L	20.1
Acanthopanax sessiliflorus	Ulmaceae	L	27.4
Liriodendron tulipifera	Magnoliaceae	L	24.7
Magnolia liliflora	Magnoliaceae	L	21.9
Rhododendron mucronulatum	Ericaceae	L	21.1
Rhododendron schlippenbachii	Ericaceae	L	16.8
Colocasia antiquorum var. *esculenta*	Araceae	L	23.5
Ricinus communis	Euphorbiceae	L	26.4
Chionanthus retusa	Oleacae	L	20.4
Syringa reticulata var. *mandshuricas*	Oleaceae	L	12.8
Thujopsis dolabrata var. *hondai*	Cuppuraceae	SD	1.2

[1]L, leaf; S, stem,; SD, sawdust.

[2](Weight/dry weight of test material)$\times$100.

veral years without exposure to any insecticide in our laboratory. Laboratory rearing procedures were the same as previously described.[9-11]

Plants and sample preparation

The plant species are anecdotally selected and listed in Table 1. The sawdust of *Thujopsis dolabrata* S. et. Z. var. *hondai* was obtained from Aomori Forest Experimental Station, Aomori, Japan. The crude oil of the plant sawdust was obtained by steam distillation as previously described.[12] Three plant species (*P. koreana, E. hyemale* and *P. aquilinum*) were purchased from oriental medicinal plant market in Seoul. Fully developed leaves from the other 39 plant species were collected during mid-July to August 1992 at the Forestry Research Institute, Seoul, Korea. These were dried in a blower at 60℃ for 3 days, finely powdered using a blender, extracted twice with methanol at 25℃ 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

In relation to the search for new bioactive substances against insect pests, we established a bioassay method suitable for rapid mass screening of synthetic organic compounds or plant-derived extracts for insecticidal and acaricidal activities with reproducible results, using only a minute quantity of compounds.[9-11] The plant extracts were tested at a concentration of 8,000 ppm for insect species and 4,000 ppm for mite. If a plant extract exhibited activity, titration studies were performed. Test samples suspended in distilled water with Triton X-100 added at the rate of 0.1 ml/liter were used.

Spray method was used for the bioassay of *N. lugens.* Twenty female adults were transferred onto a test tube (3×20 cm) containing five 'Chucheong' rice seedlings wrapped with cotton and about 20 ml water. Spray was applied with a glass spray unit connected to a forced air supply (Pacific Chemical Co., Ltd., Seoul).

Leaf-dipping method was used for aphid, lepidopteran larvae, and mite. Leaves of bean (*Glycine max*) for *M. persicae,* chinese cabbage (*Brassica campestris* subsp. *napus* var. *pekinensis*) for *P. xylostella* and *S. litura,* and kidney bean (*Phaseolus vulgaris* var. *humilis*) for *T. urticae* from each plant species grown in green house were collected, and disks (3 cm dia.) were punctured from each leaf. Three leaf disks were dipped in test solution for 30 sec, as previously described.[10] After evaporation in a hood for 2 hr, 20 second larvae of each *P. xylostella* and *S. litura* and 20 *M. persicae* females and 30 *T. urticae* adults were placed onto the treated and control leaf disks in Petri dishes.

In the case of *S. oryzae* and *B. germanica,* following procedure was employed. Filter paper was dipped into the solution of the test samples. After evaporation, ten female adults of each *S. oryzae* and *B. germanica* were placed into polystrene cup that contained the treated paper. Each container was covered with lid to prevent the two insect species escaping. Weevils and cockroaches used in the controls were exposed to paper treated with solution only.

All treated materials were held in a room at 25± 1℃, 50~60% RH, and a photoperiod of 16 : 8 (light/dark). Mortality was counted after 48 hr, and all treatments were done in triplicate. The insecticidal and acaricidal activities were classified as follow: the stongest activity +++, mortality>80%; moderate ++, mortality 80~60%; weak +, mortality 59~40%; and no activity, mortality<40%.

Results and Discussion

Insecticidal activity

Methanol extracts of 43 plant species were prepared and subjected to a screening test for their insecticidal activities for six species of insect pests. The most important factor in the primary screening for bioactive substances may be the starting concentration. In a previous paper,[10] we reported that a concentration of 8,000 ppm of a plant extract did not cause any problem such as solubility and detection of minor active components. At a concentration of 8,000 ppm, the methanol extract of *G. biloba* leaves showed potent selective insecticidal activity only against *N. lugens* (+ + +). However, steam distillate of *T. dolabarata* var. *hondai* sawdust showed potent insecticidal activity (+ + +) against all test insects (*N. lugens, P. xylostella, S. litura, M. persicae, S. oryzae,* and *B. germanica*). The other plant extracts were nontoxic to all test insects.

Due to the potent insecticidal activities of *G. biloba* and *T. dolabarata* var. *hondai* extracts, titration studies were performed. The *G. biloba* extract exhibited 100% mortality against *N. lugens* at a concentration of 500 ppm. Significant insecticidal activities against all test insect species were also observed with the 500 ppm of crude oil from *T. dolabarata* var. *hondai* sawdust.

Certain plant-derived extracts and phytochemicals can be useful not only as insecticides, but also in reducing plant damage below the economic injury level. They are being considered as potenial alternatives for synthetic insecticides.[5,6,13] 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.[14] Among the variety of plants, neem (*Azadirachta indica* A. Juss)-derived extracts have shown great potential in controlling insect pests.[15] This plant belongs to the family Meliaceae. In the present paper, the methanol extract of *G. biloba* leaves showed potent insecticidal activity against *N. lugens*, although this plant belongs to the family Ginkgoaceae. This is the first report on insecticidal activity of *G. biloba* leaves against *N. lugens*, although this plant has long been considered to have natural properties.

Acaricidal activity

In a preliminary test, a concentration of 8,000 ppm was too sticky for *T. urticae* to move and the mites died inevitably. Therefore, 4,000 ppm was chosen as a starting concentration for the acaricidal activity. The activity against *T. urticae* was plant species dependent. Because 26 species among the 43 test plants showed some activity at the concentration of 4,000 ppm, titration studies were performed (Table 2). The following six exhibited significant activity at a concentration of 2,000 ppm: *R. communis, P. densiflora, C. antiquorum* var. *esculenta, S. officinalis, E. hyemale* and *T. dolabarata* var. *hondai*. The most significant activity was observed for *P. densiflora* and *T. dolabarata* var. *hondai*

T. urticae was a minor pest until the late 1950's.

Table 2. Acaricidal activity of plant extracts against *Tetranychus urticae*

Plant speces tested	Activity/Conc(ppm)		
	4,000	2,000	1,000
T. kiusiana	+	−	−
W. floribunda	++	−	−
R. pseudo−acacia	+	−	−
T. repens	++	−	−
S. officinalis	++	++	−
E. hyemale	+++	++	−
G. biloba	++	+	−
P. asiatica	++	−	−
C. sinensis	+	−	−
P. koreana	+	−	−
C. moschata	+	−	−
P. aquilinum var. *latiusculum*	++	−	−
A. princeps var. *orientalis*	++	−	−
P. densiflora	+++	+++	++
C. tricuspidata	+	−	−
A. ginnala	+	−	−
A. mangostranus	+	−	−
A. sessiliflorus	+	−	−
L. tulipifera	++	−	−
R. mucronulatum	++	−	−
R. schlippenbachii	+++	−	−
R. communis	+++	++	−
C. retusa	++	−	−
S. reticulata var *mandshurica*	++	−	−
C. antiquorum var. *esculenta*	+++	++	−
T. dolabrata var. *hondai*	+++	+++	++

[a]Plant species showing no acaricidal activity are not presented in the Table 2.

However, continued use of insecticides and acaricides during the past decades has disrupted the control of *T. urticae* populations by natural enemies and has led to the outbreaks and resurgences, and the development of a widespread resistance to acaricides or the acaricide groups.[16] Decreased efficacy and increasing concern over adverse effects of the earlier types of acaricide have brought about the need for alternative effective acaricides. However, little information is available for plant-based materials. In the present study, the methanol extracts of some plant species showed potent acaricidal activity, suggesting that they might be useful for developing new types of acaricides or biorational management agents for controlling *T. urticae* populations.

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식물체 추출물의 살충 및 살비활성

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초록 : 43종 식물체 추출물의 6종 해충(벼멸구, 배추좀나방, 담배거세미나방, 복숭아혹진딧물, 쌀바구미, 독일바퀴)에 대한 살충활성 및 응애에 대한 살비활성을 조사하였다. 은행잎 메탄올 추출물은 벼멸구에 대해서만 선택적으로 강한 살충활성을 보인 반면, 나한백의 일종인 *Thujopsis dolabrata* var. *hondai* 톱밥의 수증기증류물은 모든 공시충에 대해 높은 살충활성을 보였다. 소나무잎 메탄올 추출물과 *T. dolabrata* var. *hondai* 톱밥의 수증기증류물은 점박이응애에 대해 강한 살비활성을 나타내었다.