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Insecticidal and Acaricidal Activities of African Plant Extracts against the Brown Planthopper and Two-Spotted Spider Mite

아프리카산 식물체 추출물의 벼멸구 및 점박이응애에 대한 살충 및 살비활성

I. G. Hiremath[1], Young Joon Ahn[1]*, Soon Il Kim[1], Byung Ryul Choi[2] and Jum Rae Cho[2]
I. G. Hiremath[1] · 안용준[1]* · 김순일[1] · 최병렬[2] · 조점래[2]

ABSTRACT Total 31 samples from 21 African plant species in 13 families were tested for their insecticidal and acaricidal activities against *Nilaparvata lugens* (Stål) and *Tetranychus urticae* (Koch) adults through topical application and leaf-dipping methods, respectively. The insecticidal and acaricidal activities were both plant parts and species dependent. The methanol extracts from whole plants of *Cassia occidentalis* and *Cassia tora* (Caesalpinaceae), and stem of *Prosopis chinensis* (Mimosaceae) revealed potent insecticidal activity against *N. lugens*. Potent acaricidal activity against *T. urticae* was obtained from the methanol extracts from whole plants of *Celosia trigyna* (Amaranthaceae) and *Combretum micronthum* (Combretaceae), leaves of *Combretum glutinotum*, and leaves and fruits of *Prosopis chinensis*

KEY WORDS Insecticidal activity, acaricidal activity, African plant, *Nilaparvata lugens*, *Tetranychus urticae*

초 록 아프리카 나이제르산 13과 21종 식물체의 부위별로 채집된 31 시료 메탄올 추출물의 벼멸구에 대한 살충활성 및 점박이응애에 대한 살비활성을 각각 미량국소처리법과 잎침지법으로 조사한 결과, 시료의 부위 및 종에 따라 살충 및 살비활성에 커다란 차이를 보였다. Caesalpinaceae과의 *Cassia occidentalis*와 *Cassia tora* 전부위 및 Mimosaceae과의 *Prosopis chinensis* 줄기의 메탄올 추출물은 벼멸구에 대해서 강한 살충활성을 보인 반면, 비름과의 *Celosia trigyna* 전부위, Combretaceae과의 *Combretum glutinotum* 잎과 *Combretum micronthum* 전부위 및 *Prosopis chinensis* 잎과 열매의 메탄올 추출물은 점박이응애에 대해 강한 살비활성을 나타내었다.

검색어 살충활성, 살비활성, 아프리카산 식물, 벼멸구, 점박이응애

The brown planthopper (*Nilaparvata lugens* Stål) and two-spotted spider mite (*Tetranychus urticae* Koch) are serious arthropod pests of rice plants (Dyck & Thomas 1979), and vegetable and fruit crops (Helle & Sabelis 1985), respectively. If not managed properly, these species cause serious yield losses when nymphs and adults excessively feed on the developing crops. Control is primarily dependent upon continued or repeated applications of insecticides or acaricides. Although they have effectively controlled these pests, their extensive use for the past decades has disrupted control of these arthropod populations by natural enemies and has led to outbreaks of these pests (Ripper 1956, Chelliah & Heinrichs 1980), and the development of widespread resistance to various types of these organic chemicals (Georghiou & Saito 1979, National Research Council 1986). Decreased efficacy and increasing concern

[1]Department of Agricultural Biology and Research Center for New-Biomaterials in Agriculture, College of Agriculture and Life Sciences, Seoul National University, Suwon 441-744(서울대학교 농생물학과 및 농업생물신소재연구센터, 수원 441-744)
[2]Department of Plant Protection, National Agricultural Science and Technology Institute, RDA, Suwon 440-717, Republic of Korea(농촌진흥청 농업과학기술원 작물보호부, 수원 440-717)
*Corresponding author

over adverse effects of the earlier types of these chemicals 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 chemicals.

Because plants virtually are the richest source of bioactive organic compounds (Namba 1986, Harborne 1988), in recent years much concern has been focused on plant materials for potentially useful products as commercial insecticides (Jacobson & Crosby 1971, Elliott 1977, Arnason *et al.* 1989) or as lead compounds for synthetic insecticides (Elliott 1977, Balandrin *et al* 1985, Miyakado *et al.* 1989) However, little information is available for African plant-based materials against *N. lugens* and *T. urticae*.

In the laboratory studies described herein, we assessed the insecticidal and acaricidal activities of methanol extracts of total 31 samples from 21 African plant species in 13 families against *N. lugens* and *T. urticae*.

MATERIALS AND METHODS

Test Organisms

Two species of arthropod pests were used in this study The laboratory strain of *Nilaparvata lugens* (Stål) has been maintained in laboratory for 14 years without exposure to any insecticide. The susceptible strain of *Tetranychus urticae* (Koch) was obtained in 1992 from Dr. N. Motoyama, Chiba University, Japan. Laboratory rearing procedures are the same as previously described (Cho *et al.* 1987).

Plants and Sample Preparation

The plant species are anecdotally selected and listed in Table 1. Different parts namely leaf, stem, fruit, and whole plant were collected in Niger (West Africa) during October 1993. Economic importance of these plants were described in details by Schmelzer (1991). Each plant material was chopped into small pieces, dried in a blower at 60°C for 2 days and finely powdered using a blender. Each sample was mixed with methanol (1 · 3, wt/wt) and incubated at 25°C for 48 hr, then was filtered (Toyo filter paper No. 2). The extraction was done twice to get better yield The combined filtrate was concentrated *in vacuo* at 35°C, using rotary vacuum evaporator. Yield of each extraction is shown in Table 1. The simple statistic 'Standard deviation (SD)' was used to classify the plant samples based on their methanol extract yield: high yielder, yield>mean+SD; moderate yielder, yield between mean+SD and mean−SD; low yielder, yield<mean−SD.

Toxicity Test

Topical application method by microapplicator (Burkard Scientific, UK) was used for insecticidal activity of test plant samples against *N. lugens*. In primary screening test, 1 0 μg of each sample in 0.25 μl of acetone or methanol was topically applied to the dorsum of the thorax of 4- to 5-day-old *N. lugens* female adults. Control planthoppers received acetone or methanol only. If a plant extract exhibited activity, titration studies were performed. All treatments were conducted in triplicate, and 20 females were used in each assay

Leaf-dipping method was used for acaricidal activity of test plant samples against *T. urticae* adults. Leaves of kidney bean (*Phaseolus vulgaris* var. *humilis* Alefeld) grown in green house were collected, and disks (φ 3 cm) were punctured from each leaf. The plant extracts were tested at a concentration of 5,000 ppm, as previously described (Ahn *et al* 1992, Kwon *et al.* 1994). Plant samples showing strong activity at 5000 ppm were further evaluated at 2.500 ppm. Test samples suspended in distilled water with Triton X-100 added at the rate of 0.1 ml/liter were used. Three leaf disks were dipped in test solution for 30 sec, as previously described (Ahn & Cho 1992). After evaporation in a hood for 2 hr, *T. urticae* adults were placed onto the treated and control leaf disks in Petri dishes. All treatments were conducted in triplicate, and 30 adults were used in each assay.

All treated materials were held in a room at 25 ± 1°C, 50~60% relative humidity, and a photoperiod of 16 : 8 (L : D) hr, and mortality was determined 48 hr after treatment. Data from all bioassays were corrected for control mortality using Abbott's (1925) formula The insecticidal and acaricidal activities were classified as follow: strong activity +++,

Table 1. African plants screened for insecticidal and acaricidal properties

Plant name	Family	Part tested[a]	Yield (%)
Amaranthus viridis	Amaranthaceae	Wp	26.7
Blepharis linarifolia	Amaranthaceae	Wp	20.1
Blepharis sp.	Amaranthaceae	Wp	24.5
Celosia trigyna	Amaranthaceae	Wp	31.9
Azadirachta indica	Meliaceae	L	26.0
Balanites aegyptiaca	Zygophyllaceae	St	19.1
		L	21.0
Boirerio radiata	Rubiaceae	Wp	19.7
Boscia senagalensis	Capparidaceae	St	19.3
		L	29.2
Clome viscosa	Cappandaceae	Wp	22.5
Bougainvillea spectabilis	Nyctaginaceae	L	24.3
		St	22.0
Calotropis gigantea	Asclepiadaceae	L	24.5
Cassia mimosoides	Caesalpiniaceae	L	22.4
Cassia occidentalis	Caesalpiniaceae	Wp	25.0
Cassia tora	Caesalpiniaceae	Wp	29.1
Combretum glutinotum	Combretaceae	L	20.2
		St	18.9
Combretum micronthum	Combretaceae	Wp	25.5
Piloitigma vetilicolin	Combretaceae	Wp	27.2
Guiera senagalensis	Combretaceae	L	26.1
		St	19.2
Corchorus sp.	Malvaceae	Wp	23.4
Hybiscus sp.	Malvaceae	Wp	27.1
Ipomoea asarifolia	Convolvulaceae	Wp	26.0
Ipomoea sp	Convolvulaceae	Wp	25.0
Prosopis chinensis	Mimosaceae	Fr	20.0
		L	21.2
		St	23.0
Waltheria indica	Sterculiaceae	Wp	29.3

[a]L, leaf. St, stem; Fr, fruit; and Wp, whole plant.

mortality>80%; moderate ++, mortality 80~61%; weak +, mortality 60~40%; and no activity, mortality<40%.

RESULTS

Yield of Methanol Extract

Total 31 samples consisting of leaf (9), stem (6), fruit (1) and whole plant (15) belonging to 21 African plant species in 13 families were extracted (Table 1). Yield of methanol extract ranged from 18.9% in *C. glutinotum* (Combretaceae) stem to 31.9% in *C. trigyna* (Amaranthaceae) whole plant. The average yield was 23.9%. Out of 31 samples, the high yielders which yielded more than mean+SD (23.9+3.5=27.4) per cent were only 4 belonging to Capparidaceae, Sterculiaceae, Amaranthaceae and Caesalpiniaceae. Total 20 samples were grouped as moderate yielders, while 7 samples were classified as low yielders.

Insecticidal Activity against *N. lugens*

Methanol extracts of the African plant species were subjected to a screening test for their insecticidal activities for *N. lugens* using topical application method. The most important factor in the primary screening for bioactive substances may be the starting dose. In a previous paper (Ahn *et al.* 1992), we reported that a dose of 1.0 μg/female of a plant extract did not cause any problem such as solubility and detection of minor active components.

Insecticidal activity was both plant parts and species dependent (Table 2). At a dose of 1.0 μg/female, 14 samples had strong and moderate activity. The following three samples revealed a significant activity (+++): whole plants of *C. occidentalis* and *C. tora* (Caesalpinaceae), and stem of *P. chinensis* (Mimosaceae).

Due to the moderate and strong insecticidal activities of 14 samples, titration studies were performed. The extracts of *Blepharis* sp. (Amaranthaceae) whole plant, *C. occidentalis* and *C. tora*, *Ipomoea* sp. (Convolvulacess) whole plant, and *P. chinensis* exhibited moderate activity (++) at a dose of 0.5 μg/female. However, all samples failed to show either moderate or strong activity at 0.1 μg/female.

Acaricidal Activity against *T. urticae*

In a primary screening test with *T. urticae* adults, 5,000 ppm was chosen as a starting concentration for the acaricidal activity. The acaricidal activity was both plant parts and species dependent (Table 3). All samples except *B. spectalis* stem revealed acaricidal activity. Because 16 samples out of these 31 showed strong (+++) acaricidal activities at 5,000 ppm, these samples were further evaluated at 2500 ppm. The following five samples exhibited a signifi-

Table 2. Insecticidal activity of African plant extracts against *Nilaparvata lugens*

Plant name[a]	Plant part	Activity[b] 1.0[c]	0.5	0.1
A. viridis	Wp	+		
B. linarifolia	Wp	++	+	−
Blepharis sp	Wp	++	++	−
C. trigyna	Wp	+		
A. indica	L	++	+	−
B. aegyptiaca	L	++		
	St	−		
B. radiata	Wp	++	+	+
B. senagalensis	L	+		
	St	−		
C. viscosa	Wp	−		
B. spectabilis	L	+		
	St	+		
C. gigantea	L	−		
C. mimosoides	L	−		
C. occidentalis	Wp	+++	++	+
C. tora	Wp	+++	++	+
C. glutinotum	L	−		
	St	−		
C. micronthum	Wp	+		
P. vetilicolin	Wp	++	+	−
G. senagalensis	L	+		
	St	−		
Corchorus sp.	Wp	+		
Hybiscus sp.	Wp	++	+	−
I. asarifolia	Wp	+		
Ipomoea sp.	Wp	++	++	+
P. chinensis	L	++	+	+
	St	+++	++	+
	Fr	+++	+	+
W. indica	Wp	++		

[a] Plant samples showing >75% mortality at 1.0 μg/female were further evaluated at 0.5 and 0.1 μg/female.
[b] Mortality >80%, +++; 61 to 80%, ++; 40 to 60%, +; <40%, −.
[c] μg/female

Table 3. Acaricidal activity of African plant extracts against *Tetranychus urticae*

Plant name	Plant part[a]	Activity[b] 5000	2500
A. viridis	Wp	+	+
B. linarifolia	Wp	++	++
Blepharis sp	Wp	+++	++
C. trigyna	Wp	+++	+++
A. indica	L	++	++
B. aegyptiaca	L	+++	++
	St	++	+
B. radiata	Wp	+	+
B. senagalensis	L	+++	++
	St	++	+
C. viscosa	Wp	+++	++
B. spectabilis	L	++	++
	St	−	−
C. gigantea	L	++	+
C. mimosoides	L	+++	++
C. occidentalis	Wp	++	++
C. tora	Wp	+++	++
C. glutinotum	L	+++	+++
	St	++	+
C. micronthum	Wp	+++	+++
P. vetilicolin	Wp	+++	++
G. senagalensis	L	+++	++
	St	++	+
Corchorus sp.	Wp	++	++
Hybiscus sp	Wp	+++	-
I. asarifolia	Wp	+++	+
Ipomoea sp.	Wp	+++	++
P. chinensis	L	+++	++
	St	++	+
	Fr	+++	++
W. indica	Wp	++	+

[a] For explanation, see Table 1.
[b] Unit, ppm

cant activity (+++): *C. trigyna* whole plant, *C. glutinotum* leaves, *C. micronthum* (Combretaceae) whole plant, and leaves and fruits of *P. chinensis*.

DISCUSSION

In the laboratory study with *N. lugens* and *T. urticae* adults, insecticidal and acaricidal activities were both plant parts and species dependent. The plants belonging to the families Caesalpiniaceae and Mimosaceae, and Amaranthaceae, Combretaceae and Mimosaceae showed strong insecticidal and acaricidal activities, respectively. However, 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.

Certain plant-derived extracts and phytochemicals can be useful not only as insecticides, but also in reducing plant damage below the economic injury level Since these are often active against a limited number of species including specific target insects, effective on insecticide-resistant insect pests, easily biodegradable to nontoxic products, and potentially suitable for use in integrated pest management programs, they are being considered as potential alternatives for synthetic insecticides (Jacobson & Crosby 1971, Elliott 1977, Arnason *et al.* 1989). For example, derivatives of *Ginkgo biloba* L. (Ginkgoaceae) among 42 oriental medicinal plants had potent insecticidal activity against the susceptible *N. lugens* comparable to the commonly used carbofuran and fenobucarb, and insecticide-resistant *N. lugens* (Kwon *et al.* 1995). However, 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 insect pests without any adverse effects on non-target organisms (Saxena 1989).

In our study, the methanol extracts of *C. occidentalis, C. tora,* and *P. chinensis* showed potent insecticidal activity against *N. lugens,* whereas potent acaricidal activity against *T. urticae* was obtained from the methanol extracts of *C. trigyna, C. glutinotum, C. micronthum,* and *P. chinensis.* This is the first report on pesticidal activity of these plants against these arthropod pests. Taniguchi *et al.* (1985) indicated that *Fagara* spp. (Rutaceae) in East Africa contain biocidal alkaloids, suggesting that these African plants used in the folk medicine and in traditional pest management practices (Schmelzer 1991) could continue to yield interesting and potentially useful research.

Based upon our results and these earlier findings, the African plants tested might be useful for developing new types of insecticides and acaricides, or biorational management agents for controlling *N. lugens* and *T. urticae* populations.

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