ANTIFEEDANT EFFECT OF JATROPHA CURCAS L. SEED OIL AND EXTRACTS ON THE VARIEGATED GRASSHOPPER, ZONOCERUS VARIEGATUS L. (ORTHOPTERA: ACRIDIDAE)

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ABSTRACT

Studies were done to determine the effect of Jatropha curcas L. seed oil and various solvent extracts on survival and feeding rates of the variegated grasshopper, Zonocerus variegatus L. in the laboratory. Although J. curcas seed emulsion was less effective when compared with 0.05% Cymbush (a synthetic pyrethroid), it nevertheless reduced the damage caused by Z. variegatus to cassava foliage (Manihot esculenta Crantz). The level of feeding suppression achieved with J. curcas extract (42.91%) was, however, similar to neem extract (40.89%) at 5% significance level.

The hexane extract, which gave the highest activity among the four solvent systems used in the extraction of J. curcas seeds, was separated into four fractions by column chromatography. Physicochemical characteristics of the most active fraction including iodine number, saponification number, infra-red spectrum, boiling point, refractive index were determined. A complex of functional groups were indicated. Further purification and spectroscopic analyses are required to establish the structure(s) of the bioactive components in the seed.

Keywords: Jatropha curcas, Zonocerus variegatus, feeding suppression, bioactive compounds, chromatography, functional groups.

INTRODUCTION

The role that plant-derived chemicals can play in pest management is well recognised [2,8]. Over 1,600 plant species are reported to possess pest control properties [6]. The effects of plant derivatives on organisms include feeding deterrency and inhibition [3,8], growth regulations and disruption [13] repellency [10], toxicity [9] ovipositional inhibitions [4] and sterilization [11]. The pyrethrins, rotenoids, ryanodines and recently, the derivatives of neem (Azadirachtins) are few of the phytochemicals with pests control potentials that have been developed commercially [8,9]. Efforts are, however, being made to identify more plants with pest control potential due to the problems associated with the usage of synthetic pesticides.

The physic nut, Jatropha curcas Linn is commonly grown for hedges and fences in Ghana because it is avoided by sheep, goats and termites [7]. The seed oil has been found to be an effective protectant of stored maize and cowpea against Sitophilus zeamais (Motsch) and Callosobruchus maculatus (F) [4]. This paper is a report of the effect of the seed oil emulsion and solvent extracts of the seed on Z. variegatus L.

MATERIALS AND METHODS

Insects:

Second and fourth instars Z. variegatus nymphs were collected from our experimental plot at Mesewam, five kilometers from the campus of University of Science and Technology on the Kumasi-Accra road. The insects were kept in the laboratory at room temperature (25 - 33°C) and relative humidity (65 - 85%) on cassava foliage until used.

Chemicals:

Neem and Jatropha oils were prepared from dried seed according to methods described earlier [3]. Emulsion solutions were prepared to the desired concentrations using Triton-X as emulsifier. Cymbush (100g/litre Cypermethrin, Imperial Chemical Industries, Plant Protection Division, Surrey, England) was prepared from Emulsifiable concentrate formulation. Solvent extracts were prepared

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from dried pulverised Jatropha seeds. The pulverised seeds were extracted serially in a soxhlet apparatus with diethyl ether, hexane, hexane-methanol (1:1) and water.

Topical Application Bioassay

Two microlitres each of 5% Jatropha emulsion, 5% neem emulsion, 0.05% Cymbush, diethyl ether extract, hexane extract, hexane-methanol (1:1) extract, water extract and the various fractions of the hexane extract were applied to the second abdominal segment of second instar Z. variegatus nymphs with Gallenkamp microlitre transferpette. Water or water and Triton-X mixture was used as control treatments. All the nymphs used had been starved for 18h to evacuate their intestines. Twenty-five treated nymphs were introduced into each cage holding cassava twig placed in 500ml conical flask with water to keep them fresh. Each treatment was replicated three times.

Cassava twigs, in 500ml conical flasks containing water, were sprayed to run-off (ca.250ml twig) with Jatropha emulsion at four rates (2.5, 5.0, 7.5 and 10.0%) using a hand-held mist sprayer. Control treatments were sprayed with a mixture of water and Triton-X. Twenty five fourth instar Z. variegatus nymphs starved for 18h were introduced into each cage containing treated twig. Each treatment was replicated three times. Mortality and food consumption were determined after 24h in the topical application bioassay but was extended to 48h, 72h and 96h in the foliar treatment bioassay. The effect of the various treatments on food consumption was evaluated by determining feeding suppression of the various solutions. Feeding suppression was = (% eaten in control unit - % eaten in treated unit) / (% eaten in control unit) x 100. All studies described above were conducted in the laboratory with temperature and relative humidity ranging from 25 - 33°C and 65 - 85% respectively.

Chemical Analyses

Column chromatography of the hexane extract:

A column was filled with neutral alumina using petroleum ether (40 - 60°C) as solvent. After the column was run with the same solvent for about 45mins. the hexane extract of the seeds of Jatropha was added to the top of the column and elution was continued with ethanol. Four components, A_1 (yellowish-green), A_2, (pale yellow), A_3 (yellowish green) and A_4 (palestraw colour), labelling from the bottom of the column were obtained. The effects of each of these four fractions on the test insects were determined. Thin Layer Chromatography (TLC) analysis was carried out on fraction A_1 which gave the highest activity.

Standard organic functional groups identification and physico-chemical screening tests were conducted on fraction A_1. The infra red spectrum, iodine number, saponification number, boiling point and the refractive index were also determined.

Statistical Analyses

Data were analysed using analysis of variance (ANOVA). For the percentage data, the data was transformed (Angular transformation) before analyses. Significant treatment means were separated using Fisher's Least significant difference [14]. Unless otherwise stated significance was determined at P=0.05. Feeding suppression was determined on dry faecal weights [12] and mortality was corrected using Abbots formula [1].

RESULTS AND DISCUSSION

Table 1 shows the effect of the two plant derived insecticides and the synthetic pyrethroid on second instar Z. variegatus nymphs. The corrected mortalities for the plant-derived extracts were 16% and 24% for 5% neem and 5% Jatropha emulsion respectively. These were significantly lower than the 75% recorded for Cymbush (P=0.01). Nevertheless, the reduced activity of the surviving nymphs on the plant-derived extracts indicates that damage to crop will be reduced. The level of feeding suppression achieved by the three test substances were 40.89 for 5% neem, 42.91 for 5% Jatropha and 86.03% for 0.05% Cymbush.

Table 1
Mortality and food consumption of fourth instar stage Z. variegatus topically treated with emulsion of neem oil, jatropha oil and Cymbush

Treatment	% Corrected Mortality	Mean Faecal Weights (g)
Water + 0.2% Sparkle	0.0	1.1051[a]
5% Neem emulsion	16.0 ± 3.2[a]	0.6885[b]
5% Jatropha emulsion	24.1 ± 4.5[a]	0.6096[b]
0.05% Cymbush	75.3 ± 2.5[b]	0.1534[c]

Values bearing the same letters in a row are not significantly different (P=0.05)

Fig. 1 shows the distribution of second instar nymphs in the cages. The distributional pattern observed was a reflection of the efficacy of the test solutions. The greater the efficacy of a solution, the lesser the number of nymphs found on plant and the greater the number of nymphs on cage floor or dead. Usually nymphs on cage floor are in a weak state and can hardly cause any damage. On the basis of this data the test solutions can be arranged in this order of decreasing efficacy 0.05% Cymbush > 5% Jatropha > 5% neem > Water + Triton - X. The oils of neem and jatropha have been shown to be effective protectants of stored maize and cowpea against damage by S. zeamais (Motsch) and C. maculatus L. respectively [5]. In these studies, it was found that, the plant extracts unlike cymbush largely incapacitated the grasshoppers because reversible paralysis was ob-

Results of the physico-chemical analyses of the chromatographic fraction A_1 showed that it was optically inactive with a boiling point of 218-200°C. The infra-red spectrum showed very strong absorptions at 2700-2820cm^{-1} (methyl alkanes), 1730cm^{-1} (carbonyl), 1150cm^{-1} (alkyl ether), 1080-1110cm^{-1} (C-O, in carbosylic acids and esters), 710cm^{-1} (aromatic ring). Screening tests have also confirmed the presence of Ketonic carbonyl and very high degree of

Table 2
Percent mortality and Percent feeding suppression of fourth instar Z. variegatus on various concentrations of Jatropha extracts.

Treatment	Mortality and feeding suppression after indicated time							
	24h		48h		72h		96h	
	% Corr. Mortality	% Feeding Suppression	% Corr Mortality	% Feeding Suppression	% Corr Mortality	% Feeding Suppression	% Corr Mortality	% Feeding Suppression
Water 0.2% Sparkle	0.00^a	34.53^a	0.00^a	13.06^a	3.34^a	16.76^a	3.52^a	1.61^a
2.5% Jat. emulsion	0.00^a	51.16^a	0.00^a	30.72^a	3.34^a	16.34^a	3.52^a	3.46^a
5% Jat. emulsion	0.00^a	61.25^b	0.00^a	45.02^b	3.34^a	46.13^b	3.52^a	8.73^a
7.5% Jat. emulsion	0.00^a	68.96^b	0.00^a	60.93^c	3.34^a	53.00^b	3.52^a	40.00^b
10% Jat. emulsion	6.67^b	75.01^b	6.67^b	62.61^c	6.67^b	63.50^{bc}	7.14^a	43.42^b

Values bearing the same letters in a row are not significantly different (P=0.05)

served, whereas the effects of 0.05% cymbush were largely irreversible.

Table 2 shows mortality rates and percent feeding suppression of fourth instar Z. variegatus nymphs confined on treated cassava foliage for varying periods of time. The observed mortalities were very low, ranging between 0.0 and 7.14%. Nevertheless, all the dosage levels tested suppressed feeding. Generally, the level of suppression decreased with increasing exposure time on treatment food. The reduction of activity of extracts was also concentration related; food consumption decreased with increasing concentration from 51.2% in 2.5% Jatropha emulsion to 75% in 10% emulsion within 24h.

Table 3 shows the effect of the various solvent extracts of pulverised Jatropha seeds on second instar nymphs. The hexane extract was the most active causing 79.1% feeding suppression in 24h. The difference between extracts of Hexane-methanol mixture (1:1) and water was not significantly different (P=0.05). On the other hand, diethyl ether extract had no effect on feeding.

Fraction A_1 (yellowish-green in colour) was the most active of the four fractions derived from the crude hexane extract (Table 4). It was more effective on the nymphs than the crude hexane extact. Fraction A_2 (pale yellow in colour) had similar level of activity as the crude hexane extract whilst fraction A_3 (yellowish-green in colour) was the least active fraction. Although a complex of substances may be involved in the antifeedant activity of the crude extracts of J. curcas, these results suggest that the major components for the antifeedant activity may be present in fraction A_1.

Table 3
Food consumption of second instar Z. variegatus nymphs topically treated with seed extracts of various solvents in 24 hours

Treatment	% Feeding suppression	Mean faecal wts. (gm)
Diethyl ether extract	0.0^a	1.3105^a
Hexane-methanol extract	41.6^b	0.5145^b
Hexane extract	79.1^c	0.2293^c
Water extract	45.8^b	0.4885^b

Values bearing the same letters in a row are not significantly different (P=0.05)

Table 4
Feeding consumption of second instar Z. variegatus topically treated with fractions derived from hexane seed extract.

Treatment	% Feeding suppression	Mean faecal weights (gm)
Fraction A_1	95.8^a	0.0925^a
Fraction A_2	66.7^b	0.3445^b
Fraction A_3	12.5^c	0.7855^c
Fraction A_4	37.5^b	0.5320^b
Crude Hexane extract	70.8^b	0.2927^b

Values bearing the same letters in a row are not significantly different (P=0.05).

unsaturation. Spot test TLC on silica gel C activated at 110°C for one hour in solvent systems showed that A_1 was quite pure chromatographically.

These studies have nonetheless, demonstrated the potential of derivatives of Jatropha curcas for use in pest control. The importance of J. curcas extracts for pest control can be seen from its effect on food consumption rather than its toxicity. The deterrent action of the oil emulsion and solvent extracts result in low feeding rates and less active insects that would be more susceptible to predation. Also the reduction in activity of the extracts with increasing exposure

time would minimise the risks to non-target organisms that might contact the residues.

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