Macrothink Institute™

Journal of Agricultural Studies
ISSN 2166-0379
2020, Vol. 8, No. 2

Field Response of Cowpea, *Vigna unguiculata* Walper to Four Insecticidal Compounds and Their Residual Toxicity to *Callosobruchus maculatus* (F.) [Coleoptera: Chrysomelidae] in The Laboratory

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Received: Feb. 17, 2020 Accepted: Mar. 29, 2020 Published: June 15, 2020

doi:10.5296/jas.v8i2.17184 URL: https://doi.org/10.5296/jas.v8i2.17184

Abstract

There have been paradigm shift to the use of biopesticides as alternative to synthetic pesticides in recent years due to its environment friendliness and non-toxic to the non-target organisms. Therefore, three synthetic insecticides and water extract from neem back powder were evaluated on cowpea in the field and their residual toxicity tested against *C. maculatus* in the laboratory. The insecticides were applied at the rate of 2ml in 2L of water and 2L of extract from neem back powder on the field. The harvested seeds were infested with *C. maculatus* to evaluate the residual toxicity of the insecticides. Data on growth and yield parameters were taken on the field while data on adult mortality, oviposition, adult emergence and weight loss were recorded for the laboratory experiment. The results showed positive response of cowpea to the applied chemicals as they had higher values for the number of leaves, branches and reduced number of holes. Number of holes was significant ($p < 0.05$) at the 8th week with the control having highest number of holes. Cowpea treated with cypermethrin had highest number of pods at both 7th and 8th week and showed significant difference at 7th week. Highest weight of seeds per pod was obtained from the cowpea treated with water extract from neem back powder and was significantly different ($p < 0.05$) from other treatments. Seeds treated with the three insecticides had the same number of mortality while neem extract had highest but was not significantly different ($p > 0.05$). There was a reduction in number of eggs laid, adult emergence, seeds with holes and weight loss in the seeds treated with the four insecticide compounds. It was concluded that application of the insecticidal compounds positively enhanced the performance of cowpea on the field and could protect the seeds against *C. maculatus* in the laboratory. This study revealed that water extract from back powder of neem could be used as a botanical in the protection of cowpea against seed beetles.

Keyword: *Azadirachta indica*, Cypermethrin, Insecticidal compounds, Residual toxicity

1. Introduction

Cowpea (*Vigna unguiculata* Walpers) is a legume crop which several people in African countries depend upon for several purposes: its dry grains are source of plant protein for those that are unable to afford meat, fish and egg protein (Ofuya, 2003) and an alternative to expensive animal protein sources in malnourished children (Ileke *et al.*, 2013) . Cowpea is the hope of million people of Africa for cheap protein and has appropriately been called "poor man's meat" (Aykroyd *et al*., 1982; Ofuya, 2003). In the developing countries of Africa, Asia and Latin America, cowpea has been consumed by humans since the earliest practices of agriculture (Singh *et al.*, 1986). Cowpea can be grown successfully in extreme environment such as high temperature, low rainfall and poor soil with a few inputs, subsistence farmers in the semi-arid and sub humid region of Africa are the major producers and consumers of cowpea (Fery, 2003).

Cowpea grain is important to the income of resource poor farmers as well as to the nutritional status and diet in weaning food of young children (Oparaeke *et al.*, 1998). A major threat to cowpea production and storage in developing countries in the tropic area is posed by insect pests (Adebayo and Idoko, 2012). The cowpea bruchid, *Callosobruchus maculatus* (F.), is a cosmopolitan field to store pest of cowpea. Quantitative and qualitative losses manifested by seed perforation, reductions in weight, market value and germination of seeds are caused by *C. maculatus* (Ofuya, 2003). Severe losses up to 100% in unprotected cowpea can be caused by insect pest (Akinkurolere *et al*., 2006). There have been paradigm shift to the use of biopesticides as alternative to synthetic pesticides in recent years due to its environment friendliness and non-toxic to the non-target organisms. Over the years in Nigeria and in other parts of the world, management of *C. maculatus* on the field and in storage has been dominated by chemical control using fumigants and synthetic insecticides (Park, *et al.,* 2003; Akinkurolere *et al.*, 2006). However, use of these chemicals is limited in developing countries by environmental, social, financial and safety consideration (Ofuya, 2003).

In studies it was revealed that due to the high cost of synthetic chemical insecticides, farmers and traders in most Nigeria markets indiscriminately apply cheap pesticides of high mammalian toxicity to grains and thus, expose unsuspecting buyers to chronic toxicity (Rajapakse and Van Emden, 1997; Akinkurolere *et al*., 2006). Consequently, there is an increasing interest in the area of using pesticides of plant origin in order to reduce in the problems of environmental pollution, killing of non-target species and humans, as well as reducing the cost of purchasing synthetic chemical pesticides.

Recent findings have revealed that plant oils (Adebayo, 2015), plant extracts and dry powder of different plant parts can be effective protectants of stored cowpeas (Ogunwolu and Odunlami, 1996; Rajapakse and Van Emden, 1997; Lale and Abdulrahman, 1999; Boeke *et al.,* 2001;

Akinkurolere *et al.*, 2006; Akinkurolere, 2007, Adebayo and Eyo, 2014). Therefore this study seeks to evaluate the response of a cowpea variety to field application of synthetic and bio insecticides and to assess their residual toxicity to *C. maculatus* in the treated cowpea seeds.

2. Materials and Methods

2.1 Study Site

The field experiment was conducted during the late cropping seasons of 2014 at the Teaching and Research Farm of the Federal University of Technology Akure (FUTA) while the laboratory works were done in the Analytical Laboratory of the Department of Crop, Soil and Pest Management under prevailing laboratory conductions of 28±2ºC temperature and 65±10% relative humidity.

2.2 Land Preparation

The land preparation (clearing, tilling and making of beds) was done manually using hoe and cutlass and divided into plots of 3m x 3m size. The marking, pegging and labeling of the plots were done immediately for easy identification of the various allocated treatments. The experiment containing five treatments (Dimeforce (Dimethoate), Cypertrap (Cypermethrin), Chlor 1 (Chlorpyrifos), *Azadirachta indica* (Water extract from the back of neem) and the Control (without chemical)) was laid out in a Randomized Complete Block Design (RCBD) with each replicated three times.

2.3 Planting of Cowpea

Planting of cowpea was done toward the end of late rainy season of 2014. Three to four seeds were planted per hole at a spacing of 30cm by 60cm. Thinning was done to three stands per/hole after emergence of seedlings. Weeding (as at when due) was carried out manually using hoe and by hand pulling.

2.4 Preparation and Application of Insecticides

The insecticides were purchased at a chemical shop in Arakale market, Akure while the back of neem, *Azadirachta indica* was collected from the Teaching and Research Farm of the Ahamadu Bello University, Kabba College of Agriculture, Kogi State. Equal amount (2ml) of the synthetic insecticides was mixed in 2L of water in 2L pressure sprayer. The water extract was obtained by pounding the shade-dried back of neem with mortar and pestle and about 500g powder soaked in 4L of clean warm water for 24 hours. Two liters of the filtered extract was sprayed on the plot allocated for the botanical. Spraying of chemicals commenced at four weeks after planting (WAP) and was repeated fortnightly. Data were collected on the following parameters, the plant height which was measured using ruler; the number of leaves, branches, holes and pods of the tagged plants was counted and recorded. These yield parameters were also taken; weight of pods, weight of seeds, length of the pods, weight of the seeds with the pods and number of seeds in the pods.

2.5 Assessment of Residual Toxicity Effects of the Chemical Compounds Against C. maculatus

Harvested and threshed cowpea seeds were stored in paper bags and kept in the refrigerator to prevent and halt insect infestation. Prior to setting up the experiments clean uninfested seeds were acclimatized on the laboratory bench for 24 hours. The initial weight of 20 seeds from all the treatments was taken. The 20 seeds were subsequently infested with 10 pairs of 24-48 hours old *C. maculatus* and allowed to oviposit for 2weeks. At 72 hours after infestation, number of dead adult (mortality) was observed and recorded. After 2 weeks of oviposition, beetles were sieved out of the seeds and data were collected on the number of eggs laid, number of seeds with and without eggs, number of emerged adults, and number of seeds with and without holes, weight of adults and weight loss due to infestation.

2.6 Data Analysis

All data in counts were subjected to square root transformation before performing Analysis of Variance (ANOVA) using Statistical Package for Social Sciences (SPSS) Version 15. Means were separated using Tukey´s Test at 5% level of significance.

3. Results

3.1 Insecticides Application and the Response of Cowpea on the Field

The response of cowpea to application of insecticides was presented in table 1. The results indicated increment in all the parameters measured from the 4th to 8th weeks after planting. In the 4th week, there were no significant differences in plant height, number of branches and holes when all the treatments were applied. The highest plant height was recorded in the control (91.97cm) and was not significant differently ($p>0.05$) from the least height (72.27cm). Both number of leaves and branches was highest in cowpea treated with cypermethrin which was not significantly different ($p>0.05$) from the other treatments. However, number of holes on the leaves was higher (28.00) in the control than in Chlor 1 treated cowpea (17.67). Plant height was highest in the control treatment for 4th, 6th and 8th week after planting but was not significantly different ($p>0.05$) from the other treatments. Cypermethrin treated cowpea had highest number of leaves within the same period but showed no significant difference from the other treatments. Number of branches increased with the weeks after planting with no significant differences ($p>0.05$) existed in the 4th, 6th and 8th weeks of planting. Highest number of holes on the leaves was obtained from the control and the values increased with the weeks. The least number of leaves was obtained on cowpea treated with chlor1 in the 4th and 6th weeks. However, in the 8th week least values of number of holes were recorded in cowpea treated with cypermethrin (table 1).

Table 1. Mean of plant height, number of leaves, number of branches and numbers of holes

Weeks after planting	Treatment	Plant height (cm)	Number of leaves	Number of branches	Number of holes
4	Control	91.97 ± 2.96^{a}	82.85± 4.62^{a}	18.67 ± 0.67^{a}	28.00 ± 0.00^{a}
	Dimeforce	83.2 ± 6.89^{a}	77.33 ± 7.17^{a}	19.33 ± 1.86^{a}	23.67 ± 4.91^{a}
	Cypertrap	72.27 ± 1.99^{a}	88.67 ± 8.41^{a}	19.67 ± 1.67^{a}	20.00 ± 0.00^{a}
	Chlor 1	75.47 ± 4.15^{a}	84.67 ± 2.03^{a}	19.67 ± 0.33^{a}	17.67 ± 2.91^{a}
	Neemtree	81.23 ± 3.93^{a}	87.00 ± 1.53^{a}	19.00 ± 1.15^{a}	23.00 ± 1.00^{a}
6	Control	112.83 ± 5.09^{a}	140.67 ± 16.80^{a}	22.67 ± 1.21^{a}	35.33 ± 1.76^{a}
	Dimeforce	109.3 0± 6.75^{a}	151.67 ± 20.99^{a}	25.00 ± 1.15^{a}	26.33 ± 4.91^{a}
	Cypertrap	95.53 ± 4.87^{a}	167 .58± 21.55^{a}	24.67 ± 1.67^{a}	24.33 ± 0.88^{a}
	Chlor 1	99.30 ± 0.95^{a}	159.67 ± 20.84^{a}	24.00 ± 0.58^{a}	23.33 ± 2.33^{a}
8	Control	116.53 ± 6.44^{a}	159.33 ± 13.59^{a}	29.00 ± 2.65^{a}	53.33 ± 1.20^{b}
	Dimeforce	115.43 ± 6.56^{a}	162.33 ± 19.67^{a}	27.67 ± 0.67^{a}	35.00 ± 3.21^{a}
	Cypertrap	101.52 ± 4.54^{a}	188.00 ± 21.78^{a}	28.00 ± 2.08^{a}	32.67 ± 1.20^{a}
	Chlor 1	101.87 ± 5.38^{a}	174.33 ± 6.77^{a}	27.67 ± 0.33^{a}	34.33 ± 1.45^{a}
	Neemtree	106.63 ± 2.44^{a}	152.67 ± 10.4^{a}	28.33 ± 0.67^{a}	36.67 ± 3.18^{a}

Means in the same column bearing the same alphabets superscripts were not significantly different at 5% level of significance using Turkey Test

There was a significant difference ($p<0.05$) in the number of pods at the 7th week after planting with cypermethrin having highest number of pods (77.33) compared to the lowest (32.67) recorded in the control (table 2). Although, similar result was obtained in the 8th week where highest number of pods (97.00) was recorded for cypermethrin treated cowpea while least (69.33) was recorded in the control there was no significant difference ($p>0.05$) among the treatments.

Table 2. Mean numbers of pod per plot at 7and 8 weeks after planting

Treatment	Weeks After Planting	
	7	8
Control	32.67 ± 8.69^{a}	69.33 ± 3.53^{a}
Dimeforce	63.67 ± 7.06^{bc}	95.00 ± 4.04^{a}
Cypertrap	77.33 ± 12.12^{c}	97.00 ±11.24^{a}
Chlor 1	37.33 ± 7.45^{ab}	85.67 ± 2.19^{a}
Neemtree (Back extract)	42.00 ± 7.02^{ab}	77.00 ± 8.74^{a}

Means in the same column bearing the same alphabets superscripts are not significantly different at 5% level of significance using Turkey Test

The total weight of pods was highest in cypermethrin treated cowpea (571g) and the least in the control (215.67g) though were not significantly different ($p>0.05$) from each other. The total weight of seeds was highest (368g) in dimethionate treated cowpea which was not significantly different from the other treatments (Table 3). Longest pod (58.20cm) was obtained in cypermethrin treated cowpea but showed no significant difference ($p>0.05$) from Chlor 1 treated cowpea with pod length of 55.73cm. Cowpea treated with the neem bark extract had highest weight of the seeds in pods (7.67g) and was significantly different ($p<0.05$) from 4.00g recorded in the control.

Table 3. Means of the total weight of pods, total weight of seeds and length of pods of cowpea sprayed with the chemical compounds

Treatments	Total weight of pods (g)	Total weight of seeds (g)	Length of pods (cm)	Weight of seed in a pod (g)
Control	215.67 ±102.98 ^{a}	132.00 ±67.10 ^{a}	56.13 ±0.23 ^{a}	4.00 ±1.16^{a}
Dimeforce	544.00 ±284.42 ^{a}	368.00 ±185.26 ^{a}	57.53 ±2.85 ^{a}	7.00 ±1.00^{b}
Cypertrap	571.00 ±101.37 ^{a}	285.00 ±51.93 ^{a}	58.20 ±1.17 ^{a}	6.33 ±0.33^{ab}
Chlor 1	339.33 ±95.12 ^{a}	170.33 ±47.14 ^{a}	55.73 ±1.13 ^{a}	6.33 ±0.33^{ab}
Neemtree	290.00 ±180.50 ^{a}	246.00 ±101.30 ^{a}	57.50 ±2.75 ^{a}	7.67 ±0.33^{b}

Means in the same column bearing the same alphabets superscripts were not significantly different at 5% level of significance using Turkey Test.

3.2 Residual Toxicity Effects of Applied Treatments on the C. Maculatus

More adults (3.7) died 72 hours after infestation of the cowpea seeds treated with neem bark extract but was not significantly different from the mortality in the control (1.7). Highest number of eggs was laid by *C. maculatus* on the seeds from the control plots. Similar result was obtained for the number of emerged adults and seeds with holes where no significant differences ($p>0.05$) was observed. Number of seeds without holes also was not different significantly in all the treatments. Weight loss occasioned by the beetle was significantly different ($p<0.05$) with highest weight loss obtained from the control (0.74g) while the least was obtained from the chlor1 treated cowpea (0.40g).

Table 4. Means of mortality, eggs laid, emerged adults, seeds with hole, seeds without hole and weight Loss

Treatment	Mortality	Oviposition	Emerged Adults	Seeds with Hole	Seeds Without Hole	Weight Loss
Control	1.7^{a}	174.0^{a}	42.3^{a}	16.7^{a}	3.3^{a}	0.74^{a}
Dimeforce	2.0^{a}	142.0^{a}	34.3^{a}	16.0^{a}	4.0^{a}	0.42^{b}
Cypertrap	2.0^{a}	165.0^{a}	36.7^{a}	13.7^{a}	6.3^{a}	0.55^{ab}
Chlor 1	2.0^{a}	117.0^{a}	34.7^{a}	16.0^{a}	4.0^{a}	0.40^{b}
Neem extract	3.7^{a}	142.0^{a}	31.3^{a}	15.3^{a}	4.7^{a}	0.42^{b}

Means in the same column bearing the same alphabets superscripts were not significantly different at 5% level of significance using Turkey Test.

4. Discussion

The cowpea variety used in this study responded to the applied chemicals differently. Application of insecticides increased number of leaves, branches and reduced number of holes on the leaves. This effect consequently increased yield of the crop. The increased number of leaves and reduced holes on the leaves could have resulted in compensatory increase in other yield parameters. This observation agreed with works by other researchers (Stern, 1973; Karungi *et al*., 2000; Panhwav, 2002). The measured parameters increased with the weeks after planting.

There was an increment in the number of pods from the 7th to 8th week after planting. Cowpea sprayed with the insecticidal compounds had higher number of pods compared with those of control. Adebayo *et al.* (2013) had reported enhanced yield in cowpea when sprayed with insecticides. They observed increase in number of pod, weight of seeds and length of pods when insecticidal compound were applied. In this study values of parameters in table 3 showed that application of chemicals caused positive response of cowpea to the treatment compared with the control. This could be as a result of decimation of the insect populations on the plant. Fugile (1998) and Garby 1998) had reported similar observation when other powder or solution form of plant extracts were applied. The resultants decrease in the population of the insects could be due to the mode of actions of these chemicals which could be antifeedant, inhibition of feeding or actual killing of the insects (Adebayo *et al*., 2013).

Although significant differences were not observed in most of the parameter measured in the residual toxicity test as revealed in the study, however, application of chemicals caused higher insect mortality; reduced number of eggs laid and emerged adults. Seeds with hole were highest while seeds without holes were least in the control. Weight loss was also highest in the control. The reason for the high weight loss in the control was the ability of the beetle to survive and develop on the untreated seeds of cowpea. These observations were similar with the reports of previous works of Adebayo and Idoko (2012) and Adebayo and Eyo (2014). The effects of treatment application which caused mortality, reduced oviposition and adult emergence and weight loss have also been reported in previous studies (Ashamo, 2007; Oni, 2009; Idoko and Adebayo, 2011). The effectiveness of the insecticidal compounds on the treated seeds could indicate or suggest the presence of residue of the compounds in the seeds after harvest.

Absence of these compounds in the seeds from the control plots could be responsible for the better performance of the *C. maculatus* compared to where insecticidal compounds were applied.

5. Conclusion and Recommendations

It was concluded that application of insecticides positively enhance the performance of the cowpea on the field. Although, the synthetic chemicals had higher values in most occasions, neem extract compared favorably in its insecticidal effects. There seems to be residual effects of the applied chemicals on the *C. maculatus* as there were least number of dead insects, higher oviposition, number of emerged adults and low weight loss in the control treatment. It is recommended that more cowpea varieties should be screened for their performance when treated with insecticide compounds and the treated seeds should be analyzed to test for residue level of the insecticides in them.

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