Laboratory Bioassay of selected Plant extracts for the management of Cowpea weevil Callosobruchus maculatus (F.) (Coleoptera: Bruchidae)

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***Abstract*- Laboratory bioassays of ethanol and hexane seed extracts of Azadirachta indica, Jatropha curcas, Piper guineense and Eugenia aromatic were conducted for contact and residual action against Callosobrunchus maculatus (F) on cowpea at ambient temperature of 27±2ºC and relative humidity of 75-80%. The extracts were applied at 25%, 50%, 75% and100% in three replicates. Ethanol extracts of E. aromatica and A. indica gave 80-100% mortality of larvae and adult C. maculatus from 50% -100% concentration at contact while hexane extracts of all plants from 50% concentration recorded 80-100% mortality on adult and 100% mortality on larvae at all concentrations. Ethanol extracts of A. indica recorded highest mortality (80-100%) of adult at all concentration for residual action while hexane extracts of E. aromatica from 75% gave highest mortality (40.67- 90.3%) at 24hours post treatment. Ethanol extracts of all the plants recorded 100% mortality on larvae at each concentration while hexane extracts only gave 100% mortality at 100% concentration with three extracts at 24hours post treatment. Hexane extracts has more contact effects while ethanol extracts has more residual effects on adult and larvae of C. maculatus. Both solvents are potent, thus should be exploited for the extraction of plant extracts for pests control.**

Key words: **Bioassay, Callosobrunchus maculatus, plant extracts, toxicity,**

I. INTRODUCTION

Cowpea(Vigna unguiculata L.) Walp) Fabaceae is one of the most important food legumes grown in many parts of Nigeria. Cowpea is known as vegetable meat due to high amount of protein in the grain with better biological value on dry weight basis. The grain contains 26.61 % protein, 3.99 % lipid, 56.24 % carbohydrates, 8.60 % moisture, 3.84 % ash, 1.38% crude fiber, 1.51 % gross energy, and 54.85% nitrogen free extract([1]. it also fix nitrogen through its root nodule and grows well in poor soil with more than 85% sand and with less than 0.2% organic matter and low level of phosphorus. Its haulm (dried stock) is a valuable by-product, used as animal feed [2] .Cowpea is mainly grown in tropical and sub-tropical regions in the world for vegetable and grain and to lesser extent as a fodder crop. It is a most versatile pulse crop because of its smothering nature, drought tolerant characters, soil restoring properties and multi-purpose uses. More than 11 million hectares are harvested worldwide, 97% of which is in Africa. The grain yield of cowpea in Nigeria is 700kg/ ha[3].

Cowpea yield in Nigeria are low due to several biotic factors like pests and diseases. The main insect pest complex of cowpea consists of the flower bud thrips Megalurothrips sjostedti Trybom, legume pod borer Maruca vitrata Fab., and several species of pod sucking bugs of which Clavigralla tomentosicollis Stal. Is dominant, and aphids, mostly Aphis craccivora Koch [4]. Apart from these field insect pests, Callosobruchus maculatus (F) (Coleoptera: Bruchidae) insects are the most serious pest that damage stored cowpea. C. maculatus is a cosmopolitan pest of stored grain legumes,especially cowpeas, in the tropics and subtropics[4]. Pods of cowpea stored for 8 months could have as much as 50 % of the grains damaged by C.maculatus [6]. The female C. maculatus deposit eggs singly on the surface of cowpea seeds (oviposition), on hatching the larva penetrates the testa and remain in the seed until maturity causing several damages ranging from seed weight loss, reduced viability and reduced commercial value [7,8].

Control of stored products pests relies principally upon the use of gaseous synthetic fumigants like methyl bromide and phosphine. The use of methyl bromide is restricted in some countries because of its potential damage to the ozone layer [9,10] Uncontrolled application of chemical fumigants caused pesticide resistance in stored product pests. Pests have developed resistance against phosphine [11].

Due to the detrimental effects of synthetic fumigants, their uses for the control of storage insect pests are being discouraged and this necessitated the search for alternative sources for the containment of storage insect pests[12].Several plant extracts, volatile oils and compounds have been reported as effective fumigants and repellents against many stored product pests[13,14,15].In Nigerian traditionally, grains are stored with ,Aframomum melegueta seed, Capsicum nigrum seed, Allium sativum bulb,Zingiber officinale rhizome, Azadiracta indica leaves and Ocimum gratissimum leaves either in combination or singly and they have shown encouraging results. In this study, the residual and contact activities of hexane and ethanol seed extracts of Azadirachta indica, Jatropha. curcas, Piper guineense and Eugenia2aromatic were studied against adult and larvae of C.maculatus under laboratory condition

II. MATERIALS AND METHODS

A. Laboratory Rearing of Callosobruchus Maculatus

The parent stocks of Callosobruchus maculatus were reared under laboratory conditions on the seeds of cowpea (Vigna unguiculata). Forty (40) pairs of male and female adult insects were placed in a jar containing cowpea seeds. The jars were covered with its lid and they were allowed for mating and oviposition. The progenies of beetles were used for the study.

B. Test plant materials

Azadirachta indica seeds were obtained from a mother tree at Forestry Research Institute of Nigeria (FRIN), it was soaked in water for 2 days to soften the coat, the seeds were removed and air dried for four weeks. Jatropha curcas seeds, Eugenia aromatica flower buds and Piper guineense seeds were purchased at a local market (Bode market) in Ibadan, Oyo state Nigeria. They were air dried for two weeks. The dried plant samples were ground with an electric mill into a fine powder. Two hundred grams (200g) of powdered samples of each plant was weighed and separately placed into extraction chamber with a suitable plug. Two hundred and fifty milliliter (250ml) of hexane and ethanol were added to the sample in a separate flask. The extraction was done for 6hours and later the hexane and ethanol were distilled off from the flask using a quick fit pressure equalizing funnels.

C. Toxicity and Residual Bioassay

Extracts were evaluated for residual action by applying 1ml of each extracts at 25%, 50%. 75% and 100% concentrations on petri dishes lined with filter paper. Petri dishes were left for 5 minutes to drain off before five each of adult and five larvae of C. maculatus were separately introduced into each petri dishes. The contact toxicity of the extracts were assessed by applying 0.1 ml of each extracts at 25% 50%, 75% and 100% concentrations on the dorsal thoracic cavity of adult C. maculatus and on the dorsal cavity of the C.maculatus larvae. All the experiments were arranged in a Complete Randomized Design (CRD) in three replications.

D. Data Collection and Analysis

Data on the mortality of the adult and larvae of C .maculatus were recorded at 20minutes intervals for 24 hours. Data collected were subjected to Analysis of Variance (ANOVA) and significant means were separated at 5% level using Turkey's Honestly Significant Difference (HSD).

III. RESULTS

Mean percentage contact toxicity of stored adult cowpea beetle (Callosobrunchus maculatus) treated with different ethanol extracts at four concentration levels is shown in Table1 . Most of the extracts gave an effective kill of the weevil as time progressed and also as the concentration increased The contact effect of the extracts on the adult weevil were significant ($p< 0.05$) from 50% concentration at 24hours after treatment. The contact toxicity effect of hexane extracts on adult weevil followed the same trend with increased mortality as the time progressed and with increased concentrations (Table 2). There were no significant ($p>0.05$) differences among the treatments at the three levels of concentrations, though at 25% concentration in 24hours after treatment A. indica was significantly($p< 0.05$) more effective than other extracts. The contact toxicity of the ethanolic extracts A. indica was effective on larvae of C. maculatus starting from 20minutes after exposure with 50% concentration and above(Table 3). A. indica and J. curcas extracts gave 100% mortality of the larvae after 60mins of exposure starting from 75% concentration while P. guineense ethanolic extracts has the least effects on C. maculatus larvae with 80% mortality at 100% concentration 24hours after treatment. Mean percentage of contact toxicity of hexane extracts on C.maculatus larvae is shown in Table 4. Hexane extracts were more effective than ethanol extracts on the larvae of C. maculatus. All the extracts gave 100% mortality of the larvae at 24hours of exposure staring from 25% concentrations. The mean percentage residual effects of ethanol extracts on adult C. maculatus are presented in Table 5. A. indica extracts at all levels of concentration showed significantly ($p<0.05$) high efficacy on adult C. maculatus at 24hours after treatment while the residual effect of P. guineense was significantly ($p<0.05$) lower than other extracts at all levels of application. The residual effects of the hexane extracts on adult C. maculatus were less effective compared to ethanol extracts. All the extracts recorded 0% mortality at 25%- 75% concentration levels at 24hours after treatment. (Table 6). E. aromatica extracts at 100% showed highest efficacy (93.4%) mortality at 24hours after treatment . The residual effects of ethanol extracts of all the test plants were more effective than hexane extracts on larvae of C. maculatus at all concentrations levels with 100% mortality at 24 hours post treatment (Table 7).

TABLE I. Mean Contact Toxicity Of Ethanol Extracts Of Selected Plants On Adult Callosobruchus Maculatus

Treatments/concentration (g/ml)	Time of Exposure						
	20	**40**	**60**	**80**	**100**	**120**	**24HAT**
25%							
A. indica	0	0	0	0	0	20	20
P. guineense	0	0	0	0	0	0	0
J. curcas	0	0	0	0	0	0	0
E. aromatica	0	0	0	0	0	0	20
	ns	ns	ns	ns	ns	ns	ns
50%							
A. indica	0	0	0	0	0	20	40a
P. guineense	0	0	0	0	0	0	0b
J. curcas	0	0	0	0	0	0	20ab
E. aromatica	0	0	0	0	0	20	40a
	ns	ns	ns	ns	ns	ns	*
75%							
A. indica	0	0	0	0	20	20	60ab
P. guineense	0	0	0	0	20	20	40b
J. curcas	0	0	0	0	6.6	20	46.6b
E. aromatica	0	0	0	0	20	20	80a
	ns	ns	ns	ns	ns	ns	**
100%							
A. indica	20	20	0	0	0	20	100a
P. guineense	20	20	20	0	0	13.4	93.4a
J. curcas	0	0	0	0	0	20	60b
E. aromatica	20	20	20	20	20	0	100a
	ns	ns	ns	ns	ns	ns	**

Means with different letters are significantly different from each other at 5% level of probability by Turkey test. *= Significant at 5%; ** = Significant at 1%; NS= Not significant. HAT= Hours After treatment.

The residual action of hexane extracts on larvae shows that J.curcas was most effective at lower concentration (25- 75%) than other extracts (Table 8). However, at 100% concentration, A.indica, J.curcas and E. aromatica recorded 100% mortality at 24hours post treatment

TABLE II. Mean Contact Toxicity Of Hexane Extracts Of Selected Plants On Adult Callosobruchus Maculatus

Treatments/concentration (g/ml)				Time of	Exposure		
	20	**40**	**60**	**80**	**100**	**120**	**24HAT**
25%							
A. indica	0	0	0	20	40	60	80a
P. guineense	0	0	0	0	0	0	20b
J. curcas	0	0	0	0	20	40	60ab
E. aromatica	0	0	0	0	20	40	60ab
	ns	ns	ns	ns	ns	ns	*
50%							
A. indica	20	40	60	80	100	100	100
P. guineense	0	0	0	20	40	80	80
J. curcas	0	0	0	20	40	60	80
E. aromatica	20	20	40	60	80	100	100
	ns	ns	ns	ns	ns	ns	ns
75%							
A. indica	40	80	100	100	100	100	100
P. guineense	0	20	40	60	80	100	100
J. curcas	20	40	60	80	100	100	100
E. aromatica	20	40	60	80	100	100	100
	ns	ns	ns	ns	ns	ns	ns
100%							
A. indica	80	100	100	100	100	100	100
P. guineense	40	60	80	100	100	100	100
J. curcas	60	80	100	100	100	100	100
E. aromatica	60	100	100	100	100	100	100
	ns	ns	ns	ns	ns	ns	ns

Means with different letters are significantly different from each other at 5% level of probability by Turkey test. *= Significant at 5%; ** = Significant at 1%; NS= Not significant. HAT= Hours After treatment.

TABLE III. Mean Contact Toxicity Of Ethanol Extracts Of Selected Plants On Callosobruchus Maculatus Larvae

Treatments/concentration (g/ml)				Time of	Exposure		
	20	**40**	**60**	**80**	**100**	**120**	**24HAT**
25%							
A. indica	0	0	20	40	60	80	100a
P. guineense	0	0	0	0	0	0	20b
J. curcas	0	0	0	0	20	40	60ab
E. aromatica	0	0	0	20	40	60	80a
	ns	ns	ns	ns	ns	ns	**
50%							
A. indica	0	20	40	60	80	100	100a
P. guineense	0	0	0	0	0	20	40b
J. curcas	0	0	0	0	20	40	60ab
E. aromatica	0	0	20	40	60	80	100a
	ns	ns	ns	ns	ns	ns	**
75%							
A. indica	20	40	60	80	100	100	100a
P. guineense	0	0	0	0	20	40	60b
J. curcas	0	0	20	40	60	80	100a
E. aromatica	20	40	60	80	100	100	100a
	ns	ns	ns	ns	ns	ns	*
100%							
A. indica	20a	40a	60a	80	100	100	100a
P. guineense	0b	0b	0b	20	40	60	80
J. curcas	20ab	40a	60a	80	100	100	100
E. aromatica	26.6a	53.2a	73.2a	93.2	93.4	93.4	93.4
	**	**	**	ns	ns	ns	ns

Means with different letters are significantly different from each other at 5% level of probability by Turkey test. *= Significant at 5%; ** = Significant at 1%; NS= Not significant. HAT= Hours After treatment.

TABLE IV. Mean Contact Toxicity Of Hexane Extracts Of Selected Plants On Callosobruchus Maculatus Larvae

Treatments/concentration (g/ml)				Time of	Exposure		
	20	**40**	**60**	**80**	**100**	**120**	**24HAT**
25%							
A. indica	0	0	20	20	20	20	100
P. guineense	0	20	20	20	20	20	100
J. curcas	0	0	20	20	20	20	100
E. aromatica	20	20	20	20	20	20	100
	ns	ns	ns	ns	ns	ns	ns
50%							
A. indica	0b	20	20	13.4	13.4	20	100
P. guineense	20ab	20	20	20	20	0	100
J. curcas	0b	20	20	20	20	20	100
E. aromatica	40a	20	20	20	20	0	100
	**	ns	ns	ns	ns	ns	ns
75%							
A. indica	0	20	20	20	0	0	100
P. guineense	33.4	33.4	26.6	26.6	0	0	100
J. curcas	20	20	20	20	20	0	100
E. aromatica	46.6	26.6	20	6.6	0	0	100
	ns	ns	ns	ns	ns	ns	ns
100%							
A. indica	40	40	20	0	0	0	100
P. guineense	80	20	0	0	0	0	100
J. curcas	40	40	20	0	0	0	100
E. aromatica	80	20	0	0	0	0	100
	ns	ns	ns	ns	ns	ns	ns

Means with different letters are significantly different from each other at 5% level of probability by Turkey test. *= Significant at 5%; ** = Significant at 1%; NS= Not significant. HAT= Hours After treatment.

TABLE V. Mean Residual Action Of Ethanol Extracts Of Selected Plants On Adult Callosobruchus Maculatus

Treatments/concentration (g/ml)				Time of	Exposure		
	20	**40**	**60**	**80**	**100**	**120**	**24HAT**
25%							
A. indica	0	0	13.4	13.4	20a	26.6a	86.6a
P. guineense	0	0	0	0	0b	0b	0c
J. curcas	0	0	0	0	0b	0b	6.6bc
E. aromatica	0	0	0	0	6.6ab	13.4ab	33.4b
	ns	ns	ns	ns	**	*	**
50%							
A. indica	0	0	20	20a	26.6	13.4	93.4a
P. guineense	0	0	6.6ab	0b	6.6	6.6	20c
J. curcas	0	0	0b	6.6ab	0	6.6	40b
E. aromatica	0	0	0b	0b	13.4	20	46.6b
	ns	ns	**	**	ns	ns	**
75%							
A. indica	0	6.6	13.4	20a	13.4ab	26.6	93.4a
P. guineense	0	0	0	0b	0b	13.4	26.6b
J. curcas	0	6.6	0	6.6ab	13.4ab	20	60ab
E. aromatica	0	0	6.6	20a	20a	20	66.6ab
	ns	ns	ns	**	*	ns	**
100%							
A. indica	26.6a	20	20a	13.4	6.6ab	26.6	100a
P. guineense	0b	0	0b	0	0	20	40b
J. curcas	0b	0	0b	20	20a	26.6	93.4a
E. aromatica	0b	20	6.6ab	6.6	20a	20	93.4a
	**	ns	**	ns	**	ns	**

Means with different letters are significantly different from each other at 5% level of probability by Turkey test. *= Significant at 5%; ** = Significant at 1%; NS= Not significant. HAT= Hours After treatment.

TABLE VI. Mean Residual Action Of Hexane Extracts Of Selected Plants On Adult Callosobruchus Maculatus

Treatments/concentration (g/ml)				Time of	Exposure		
	20	**40**	**60**	**80**	**100**	**120**	**24HAT**
25%							
A. indica	0	0	0	0	0	0	0
P. guineense	0	0	0	0	0	0	0
J. curcas	0	0	0	0	0	0	0
E. aromatica	0	0	0	0	0	0	0
	ns	ns	ns	ns	ns	ns	ns
50%							
A. indica	0	0	0	0	0	0	0
P. guineense	0	0	0	0	0	0	0
J. curcas	0	0	0	0	0	0	0
E. aromatica	0	0	0	0	0	0	0
	ns	ns	ns	ns	ns	ns	ns
75%							
A. indica	0	0	0	0	0	20a	33.4a
P. guineense	0	0	0	0	0	0b	0b
J. curcas	0	0	0	0	0	13.4ab	33.4a
E. aromatica	0	0	0	0	13.4	20a	53.4a
	ns	ns	ns	ns	ns	**	**
100%							
A. indica	0	0	0	0	13.4	26.6	60ab
P. guineense	0	0	0	0	0	20	33.4b
J. curcas	0	0	0	0	13.4	20	53.4b
E. aromatica	0	0	13.4	20	20	26.6	93.4a
	ns	ns	ns	ns	ns	ns	**

Means with different letters are significantly different from each other at 5% level of probability by Turkey test. *= Significant at 5%; ** = Significant at 1%; NS= Not significant. HAT= Hours After treatment.

TABLE VII. Mean Residual Action Of Ethanol Extracts Of Selected Plants On Callosobruchus Maculatus Larvae

Treatments/concentration (g/ml)				Time of	Exposure		
	20	**40**	**60**	**80**	**100**	**120**	**24HAT**
25%							
A. indica	20	20	20	20	20	0	100
P. guineense	0	0	20	20	20	20	100
J. curcas	0	20	20	20	20	20	100
E. aromatica	20	20	20	20	20	0	100
	ns	ns	ns	ns	ns	ns	ns
50%							
A. indica	40a	40	20	0	0	0	100
P. guineense	0c	20	20	20	20	20	100
J. curcas	20b	20	20	20	20	0	100
E. aromatica	26.6ab	26.6	20	20	0	0	100
	**	ns	ns	ns	ns	ns	ns
75%							
A. indica	60a	40	0	0	0	0	100
P. guineense	20c	20	20	20	20	0	100
J. curcas	40b	40	20	6.6	0	0	100
E. aromatica	53.4ab	20	20	13.4	0	0	100
	**	ns	ns	ns	ns	ns	ns
100%							
A. indica	100a	0b	0b	0	0	0	100
P. guineense	40b	26.6a	26.6a	0	0	0	100
J. curcas	80a	20ab	0b	0	0	0	100
E. aromatica	73.4ab	26.6a	0b	0	0	0	100
	**	**	**	ns	ns	ns	ns

Means with different letters are significantly different from each other at 5% level of probability by Turkey test. *= Significant at 5%; ** = Significant at 1%; NS= Not significant. HAT= Hours After treatment.

TABLE VIII. Mean Residual Action Of Hexane Extracts Of Selected Plants On Callosobruchus Maculatus Larvae

Treatments/concentration (g/ml)	Time of Exposure						
	20	**40**	**60**	**80**	**100**	**120**	**24HAT**
25%							
A. indica	0	0	0	0	0	20	46.6
P. guineense	0	0	0	0	0	20	20
J. curcas	0	0	0	0	20	20	60
E. aromatica	0	0	0	0	0	20	46.6
	ns	ns	ns	ns	ns	ns	ns
50%							
A. indica	0	0	0	0	0	20	60
P. guineense	0	0	0	0	0	20	40
J. curcas	0	0	0	20	20	20	80
E. aromatica	0	0	0	0	0	20	60
	ns	ns	ns	ns	ns	ns	ns
75%							
A. indica	0	0	0	20	20	20	80
P. guineense	0	0	0	0	20	20	60
J. curcas	0	0	0	13.4	20	20	100
E. aromatica	0	0	0	20	20	20	80
	ns	ns	ns	ns	ns	ns	ns
100%							
A. indica	0	20	20	20	20	20	100
P. guineense	0	0	20	20	20	20	80
J. curcas	0	0	20	20	20	20	100
E. aromatica	0	0	0	20	20	20	100
	ns	ns	ns	ns	ns	ns	ns

Means with different letters are significantly different from each other at 5% level of probability by Turkey test. *= Significant at 5%; ** = Significant at 1%; NS= Not significant. HAT= Hours After treatment.

IV. DISCUSSION

The results of the laboratory bioassays show that the mechanisms by which ethanol and hexane extracts of plants on insect could be as a result of complete kill upon contact and/or through residual action. All the plant evaluated showed 80-100% mortality of larvae and adult C. maculatus at both contact and residual effect at 24 hours of exposure. This demonstrated the potential of the test plant extracts to control C.maculatus on stored cowpea. Extracts of A. indica, Jatropha curcas and other local plant materials have been screened at the Cocoa Research Institute of Ghana at both laboratory and small-scale field levels and the results are promising [16]

Golob [17] reported that P. guineense powder, oil, and hexane and acetone extracts have been effective in causing mortality and reducing oviposition of various insects when applied to grains and crops such as maize or cowpea. Ugwu [18] reported that leaf powders A. indica andCymbopogon citratus were found very effective in protecting Irvingia wombolu kernel against Oryzaephilus mercator in storage Anikwe,[19] reported that Magnifera indica and A. indica aqueous extracts gave significant kill of S. singularis in the laboratory. Similarly, Ugwu[20] also reported that A. indica and P. guineense extracts demonstrated great potential in controlling major insect pests of okra. Eugenia aromatica was found very effective in contact and residual effects at low concentration (25)% for both larvae and adult C. maculatus The corroborate the earlier by Adedire and Lajide,[21] that E. aromatica powder has significant contact and fumigant action against C.maculatus and that the mechanisms of its protective action against the cowpea seed beetle include direct toxicity to adults and eggs, and inhibition of oviposition by female beetles. Ofuya [22] also reported that E. aromatica powder manifested significant contact and fumigant insecticidal activity against the cowpea seed beetle four years after the dry flower buds were pulverized.

In this study, P. guineense extracts showed more of contact effect than residual effect on both adult and larvae of C. maculatus.

This supports the earlier report by Oparaeke [23] that visual observations after direct spraying of P. guineense extracts against Clavigralla tomentosicollis and Maruca larvae on cowpea plants show that P. guineense extracts first caused illusion on them and later killed them within 10–15 minutes of contact with the extracts. Similarly, Idoko and Adesina, [24] reported that sole plant powders application of P.guineense caused adults mortality, inhibited oviposition by female beetles on cowpea grains and suppressed F1 progeny emergence of C.maculatus and attributed its effect to contact toxicity. Fasakin and Aberejo [25] have also reported that pulverized plant material from P. guineense inhibited egg hatchability and adult emergence of Dermestes maculatus Degeer in smoked catfish (Clarias gariepipus) during storage. Olaiya [26] reported that the mode of action of the phytochemical present in P. guineense to be contact toxicity, he further postulated that the powder may also cause physical abrasion to the cuticle of bruchids with a resultant loss of body fluids or blockage of spiracle

Haxane extracts of J.curcas was found very effective at low concentration on C. maculatus larvae. This corroborate the report by Sabbour,and Abd-El –Raheem [27] that Jatropha curcas oil acted not only as oviposition deterrents but also adversely influence fecundity of Callosobruchus maculatus (F.) and Callosobruchus chinensis (L.) Similarly Abdoul Habou [28] reported that J. curcas seeds' oil has a toxic effect on the adults of C. maculatus and Bruchidius atrolineatus ,reduced adult survival and Oviposition by 85 to 90% in the females of both species

The contact effect of hexane extracts of all the test plants were more effective compared to ethanol extracts causing 100% mortality from 25% concentration on larvae and from 75% level of concentration on adult C. maculatus. This findings support the report by Kumar [29] reported the effectual larvicidal potential of hexane extracts of selected plant species resulting in 100% mortality at 1000 ppm. Similarly, Sharma [30] when 1000 ppm hexane and ethanol stem and leaf extracts were screened for their larvicidal efficacy against early fourth instars of A. aegypti that hexane extracts exhibited significant larvicidal efficacy causing 100% larval mortality. Ethanol extracts of the test plants however showed higher residual efficacy over hexane extracts on both larvae and adult C. maculatus while hexane extracts of the test plants showed higher contact toxicity effects on both larvae and adult C. maculatus at 24 hours post treatment

V. CONCLUSION

The study have established the potential of hexane and ethanol extracts from A. indica, P. guineense, E. aromatic and J. curcas against larvae and adult C. maculatus on stored cowpea and their practicable use in the development of insecticide for stored pests. Ethanol extract of A. indica and E. aromaticum were the most effective at each concentration for contact action on adult C. maculatus. Hexane extracts of the test plants proved higher contact toxicity over ethanol extracts of the same plant while ethanol extracts showed higher residual effects. Therefore, both solvents are potent and should be used for extraction of plant materials for the management of insect pest of stored product.

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