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EFFICACY OF SOME PLANT PRODUCTS ON THE CONTROL OF COWPEA BRUCHID (*Callosobruchus maculatus*) IN STORED COWPEA GRAINS

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Abstract: **An experiment was conducted under ambient condition (26 °C; 75% RH), in the Department of Biological Sciences Laboratory, University of Maiduguri, in Borno State, Nigeria. The aim was to determine the best plant products and method of application in the control of the cowpea bruchid (*Callosobruchus maculatus*). The four plant products treatments comprised *Acacia nilotica*, *Capsicum frutescens* L.; *Zingiber officinale* Rosc., *Khaya senegalensis* (Desv.) A. Juss, and a synthetic insecticide (Primiphos methyl 2% Dust) as standard check; and the three application methods treatments were slurry, soak and dust; and dose (0.5, 1.0, 1.5, 2.0 and 2.5 g/100 g of cowpea). The factorial experiment was laid-out in Randomized Complete Block Design, with three replicates. Results of the study showed that the plant products treatments differed significantly (P<0.05) in their effects on *C. maculatus* oviposition, adult emergence, mortality, and cowpea seed weight loss; which ranged from 13.0 - 85.0 eggs, 2.0 - 26.7 beetles, 1.6 - 24.0% and 1.31 - 9.22%, respectively. The results of the study consistently showed that the synthetic insecticide, Primiphos methyl gave significantly fewer eggs, emerged adults, very high mortality, and very low weight loss than all tested plant products, thus was the most effective against *C. maculatus*. However, *Capsicum frutescence* was the most effective among the four plant products, with significantly fewer eggs laid, fewer emerged adults, higher mortality and lower seed weight loss; followed by *Zingiber officinale*, *Khaya senegalensis* and *Acacia nilotica* in that increasing order of efficacy. Methods of application also differed significantly (P<0.05) in their effects on *C. maculatus*, in which dust was the most effective on oviposition, adult emergence, mortality and weight loss, followed by soak, then slurry.**

Keywords: **cowpea bruchid, Biological Sciences Laboratory, plant products treatments.**

1. INTRODUCTION

Plant based insecticides (PBI) have been used for many centuries (Udo, 2005) among limited resource farmers in developing countries used to control insect pests of both field crops and stored produce but their potentials was initially limited and ignored. Nicotine, rotenone and pyrethrum were popularly among the PBIs used to some extent for storage pests control and other pest in green houses (Fasunwon 2010). Some of these plant species possess one or more useful properties such as repellency, antifeedant, fast knock down, flushing action, biodegradability, broad-spectrum of activity and ability to reduce insect resistance (Anonymous 1996). However, most of them are either weak insecticidally or may require other plant species with different mode of action (depending on the ration and rate of application) to increase their potency (Oparaeke, 1997). For instance, *Xylopia acthiopica* (Dunal) is found to be weak insecticidally for control of *Callosobruchus maculatus* Fab on bruchid (Oparaeke, 1997) and on field pests of cowpea. However, dried fruits of *X. acthiopica* (African pepper or Ethiopian pepper) mixed with chillies (*Capsicum spp*) and applied to Kola nuts was found to have repellent properties against kola weevils (Dike, 1997).

The major pests of cowpea are insects and rodents. Insects are by far the most important limiting factor in the efficient storage of cowpea. Losses of up to 30 – 70% have been recorded on stored cowpea in the absence of insect pest control measures, (Anonymous, 1996). Since there is paucity of documented information on the use of plant extract/powder in pest control, this study was aimed at assessing the efficacy of four plant powder namely *Acacia nilotica* (fruits), *Capsicum frutescens L* (chilli pepper) fruit, *Zingiber officinale* (Ginger) Rhizome and *Khaya senegalensis* (Mahogany) fruits for management of insect pests of stored cowpea bruchid (*Callosobruchus maculatus*) using Slurry, Soak and Dust methods. The study provide alternative foam from plant products that will be effective, affordable and biodegradable in the control of insect pest of cowpea bruchid (*Callosobruchus maculatus)* during storage.

Objectives of the Study; The objectives of the study are to:

I. evaluate Plant Products for efficacy against cowpea bruchid *(Callosobruchus maculatus).*

II. compare the efficacy of the Plant Products and Synthetic insecticide in the control of cowpea bruchid in stored bean seeds and determine the best method of Application of these plant products.

2. MATERIALS AND METHODS

Study Area, Source of Experimental Materials and Stock Culture:

The experiment was conducted under laboratory condition in the Department of Biological Sciences, University of Maiduguri, Borno state, Nigeria. Specimen bottles and elastic band was procured from the open market while weighing machines, gauze/net and spatula was obtained from the Laboratory in the Department of Biology, University of Maiduguri. The Cowpea seeds (*Vigna unguiculata (L)* walp was obtained from farmers, of the native white Kananado. Stock culture of *C. maculatus* were maintain in the laboratory under good temperature and relative humidity on cowpea seeds. Culture method involved initial infestation with 100 females and 50males in 500 ml plastic container. As adult begin to emerge, the sample was sieved and the newly emerged adult were transferred and used for the experiment.

Preparation of Test Materials:

Slurry Method:

The parts of plant materials to be used (*Acacia nilotica, Capsicum frustencens, Zingiber officinale and Khaya senegalensis*) was obtained from different locations in Biu Local Government area. It was shed-dried and grounded into powder in a laboratory mill. The plant materials was added to 50cm^3 of distilled water per 0.5,1.0,1.5,2.0 and 2.5 grams each respectively of the plant materials. This was done to obtain a slurry of the plant materials that was used in the experiment (Udo, 2005). About 100 grams of cowpea seeds was placed each in a plastic bottle containing the different concentration of the slurry mixture. It was allowed to stand for few seconds. The treated seeds was removed and spread on the laboratory table and allowed to dry. The treated cowpea seeds was transferred into plastic bottles and infested with 5 pairs of newly emerged adult of *Callosobruchus maculatus* (2 males 3 females). The treatment was replicated three times.

Soak Method:

About 100cm^3 of distilled water was added to 0.5,1.0,1.5,2.0, and 2.5 grams each of the powder of the four plants materials to obtain a solution. These solutions containing different concentration was mixed with 100 grams of cowpea seeds and allowed to soak for few seconds and later removed and allowed to dry. The treated cowpea seeds was infested with 5 pairs of newly emerged adults of *C. Machulatus*. The treatments was replicated three times (Udo, 2005).

Dust Method:

In this method, it is the powder of all the plant materials (*Acacia nilotica, Capsicum frustencens, Zingiber officinale and Khaya senegalensis*) that was used. The plant powder of different plants was weighed at 0.5, 1.0, 1.5, 2.0 and 2.5 grams each respectively and mixed with 100 grams of cowpea seeds. It was shaken for few seconds and then infested with newly emerged adult of *C. Maculatus*.

Standard Insecticide (Pirimiphos – methyl dust 2%) A standard insecticide (Pirimiphos methyl dust 2%) was used. This was applied at 0.1, 0.2, 0.3, 0.4 and 0.5 grams per 100 grams of cowpea seeds mixed, shaken and allowed to stand for few seconds. It was then infested with newly emerged adults of *C. Maculatus*. The bottles was laid out in a randomized complete block design (RCBD) for eight weeks. During this period, observation was made on daily basis.

Data Collection and Analysis:

The following observations was made in other to obtain data

i Number of eggs laid (oviposition)

ii Number of adults that emerged from each treatment was counted.

iii Number of dead adults from each treatment and

vi Weight loss due to damage on infested seeds was recorded

The data collected was analyzed using analysis of variance (ANOVA). Separation of mean was done using LSD at 5% and 1% level of significance.

3. RESULTS

Effects of Method of Application, Plant Product and Dosage on Oviposition by *C. maculatus* in Cowpea

Table 1 shows the effects of plant product, dose and method of application on the number of eggs laid by *C. maculatus* on cowpea. The results indicated significant (P<0.05) difference in the effects of plant products on oviposition by *C. maculatus*. Mean number of eggs laid in the different plant product treatments ranged from 4.8 – 71.9, with the lowest count from Primiphos methyl and the highest from *Acasia nilitica*. The result expressed that *C. maculatus* laid significantly fewer eggs when the synthetic insecticide, Primiphos methyl was applied than all tested plant products. The number of eggs oviposited by *C. maculatus* also differed significantly among all plant products, with the lowest recorded from *Capsicum frutescence*, followed by *Zingiber officinale*, *Khaya senegalensis*, then *Acasia nilitica* in that order.

Methods of application also differed significantly (P<0.05) in their effects on oviposition by *C. maculatus* (Table 1). Mean number of eggs among the application method treatments ranged from 18.0 – 66.0, in which dust gave significantly lower egg-count than soak, which inturn resulted in lower count than slurry.

Result also indicated significant (P<0.05) differences in the effects of the different dosages on oviposition by *C. maculatus* (Table 1).

Table 1: Effects of plant product, method of application and dose on the number of eggs laid by *C. maculatus* on cowpea

Treatment	No. of eggs laid
Plant product (A)	
Acacia nilotica	71.9
Capsicum frutescence	32.8
Zingiber officinale	64.4
Khaya senegalensis	70.5
Primiphos methyl	4.8
SE±	0.43
F-test	0.0000
$LSD_{0.05}$	1.20
Method (B)	
Slurry	66.0
Soak	62.8
Dust	18.0
SE±	0.33
F-test	0.0000
$LSD_{0.05}$	0.93
Dose (C)	
0.5	54.1
1.0	51.7
1.5	49.1
2.0	46.5
2.5	43.2
SE±	0.43
F-test	0.0000
$LSD_{0.05}$	1.20

Interaction	
A x B	**
A x C	**
B x C	**
A x B x C	**

*** = significant at 1% probability level of the F-test.*

Table 2: Interaction effects of plant product x method of application x dosage on number of eggs laid by *C. maculatus*

	Method of application														
	Slurry					Soak					Dust				
	Dose					Dose					Dose				
Plant product	**0.5**	**1.0**	**1.5**	**2.0**	**2.5**	**0.5**	**1.0**	**1.5**	**2.0**	**2.5**	**0.5**	**1.0**	**1.5**	**2.0**	**2.5**
Acasia nilitica	109.3	100.0	91.00	82.7	71.0	99.3	96.7	93.3	91.3	89.3	35.0	32.7	30.7	29.3	27.3
Capsicum frutescence	59.3	55.0	52.0	49.3	45.0	47.3	46.0	43.3	40.7	35.3	6.3	4.7	4.0	3.0	1.3
Zingiber officinale	86.7	85.3	84.0	82.0	80.0	90.7	88.3	86.3	83.7	80.7	29.0	27.0	24.3	21.3	17.3
Khaya senegalensis	100.7	98.7	96.0	91.3	90.7	90.7	88.3	86.3	83.7	80.7	34.7	33.0	30.7	29.3	23.3
Primiphos methyl	11.3	10.7	9.0	6.0	3.3	9.0	7.3	4.7	3.3	2.7	2.0	2.0	1.0	0	0
SE±	1.66														
$LSD_{0.05}$	4.65														

Table 3: Effects of plant product, method of application and doses on *C. maculatus* adult emergence in cowpea

Treatment	No. of emerged adults
Plant product (A)	
Acacia nilotica	26.8
Capsicum frutescence	8.7
Zingiber officinale	32.5
Khaya senegalensis	33.9
Primiphos methyl	2.0
SE±	0.22
F-test	0.0000
$LSD_{0.05}$	0.68
Method (B)	
Slurry	27.9
Soak	27.3
Dust	7.2
SE±	0.17
F-test	0.0000
$LSD_{0.05}$	0.47
Dose (C)	
0.5	24.3
1.0	22.8
1.5	21.0
2.0	18.8
2.5	17.0
SE±	0.22
F-test	0.0000
$LSD_{0.05}$	0.68
Interaction	
A x B	**
A x C	**
B x C	**
A x B x C	**

*** = significant at 1% probability level of the F-test.*

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Table 4: Interaction effects of plant product x method of application x dosage on adult *C. maculatus* emergence in cowpea

	Method of application														
	Slurry					Soak					Dust				
	Dose					Dose					Dose				
Plant product	**0.5**	**1.0**	**1.5**	**2.0**	**2.5**	**0.5**	**1.0**	**1.5**	**2.0**	**2.5**	**0.5**	**1.0**	**1.5**	**2.0**	**2.5**
Acacia nilotica	42.3	42.3	36.0	25.3	20.7	38.7	36.7	34.7	35.0	29.7	15.0	13.0	12.7	10.7	10.0
Capsicum frutescens	15.3	13.0	11.0	9.3	8.7	16.7	15.3	14.3	12.3	10.7	2.0	1.3	1.00	0	0
Zingiber officinale	49.0	47.0	45.0	43.0	41.0	46.7	44.0	42.0	40.7	39.3	14.3	13.0	11.3	7.3	4.0
Khaya senegalensis	51.0	48.3	46.3	43.7	41.3	46.7	44.0	42.0	40.7	39.3	17.7	15.3	12.7	10.0	9.3
Primiphos methyl	5.3	5.3	3.7	1.7	0.7	4.3	3.3	2.7	2.3	0	0	0	0	0	0
SE±	0.84														
$LSD_{0.05}$	2.35														

Table 5: Effects of plant product, method of application and doses on *C. maculatus* adult mortality

Treatment	Mortality (%)
Plant product (A)	
Acacia nilotica	2.6
Capsicum frutescens	14.6
Zingiber officinale	9.0
Khaya senegalensis	4. 8
Primiphos methyl	17. 8
SE±	0.19
F-test	0.0000
$LSD_{0.05}$	0.54
Method (B)	
Slurry	5.9
Soak	7.0
Dust	16.4
SE±	0.15
F-test	0.0000
$LSD_{0.05}$	0.42
Dose (C)	
0.5	6.4
1.0	8.4
1.5	9.9
2.0	11.4
2.5	12.8
SE±	0.19
F-test	0.0000
$LSD_{0.05}$	0.54
Interaction	
A x B	**
A x C	**
B x C	Ns
A x B x C	*

*Ns = Not significant; *; ** = significant at 5% and 1% probability level of the F-test, respectively.*

Table 6: Interaction effects of plant product x method of application x dosage on adult mortality

	Method of application														
	Slurry					Soak					Dust				
	Dose					Dose					Dose				
Plant product	**0.5**	**1.0**	**1.5**	**2.0**	**2.5**	**0.5**	**1.0**	**1.5**	**2.0**	**2.5**	**0.5**	**1.0**	**1.5**	**2.0**	**2.5**
Acacia nilotica	0.3	1.0	2.3	3.3	3.7	0	2.0	2.7	3.0	3.7	2.0	2.3	4.0	4.0	5.0
Capsicum frutescens	6.7	9.0	10.7	11.0	11.3	5.3	8.3	10.3	13.0	15.3	19.3	22.3	23.7	25.7	27.3
Zingiber officinale	3.7	4.3	6.3	10.0	12.7	7.0	7.7	6.3	11.3	13.7	6.0	8.3	10.7	12.3	14.0
Khaya senegalensis	0.7	1.0	1.7	2.0	2.7	1.7	2.7	3.7	4.7	5.3	6.0	8.3	9.0	10.3	12.0
Primiphos methyl	2.3	6.7	10.7	11.3	11.7	3.3	8.0	10.7	10.7	13.3	31.3	33.7	35.7	37.7	39.7
SE±	0.74														
$LSD_{0.05}$	2.08														

Table 7: Effects of plant product, method of application and doses on weight loss in cowpea seed

Treatment	Weight loss (%)
Plant product (A)	
Acacia nilotica	6.91
Capsicum frutescens	2.20
Zingiber officinale	7.33
Khaya senegalensis	9.11
Primiphos methyl	0.76
SE±	0.30
F-test	0.0000
$LSD_{0.05}$	0.83
Method (B)	
Slurry	5.61
Soak	6.52
Dust	3.65
SE±	0.2
F-test	0.0000
$LSD_{0.05}$	0.65
Dose (C)	
0.5	7.16
1.0	6.13
1.5	4.9
2.0	4.78
2.5	3.69
SE±	0.30
F-test	0.0000
$LSD_{0.05}$	0.83
Interaction	
A x B	**
A x C	Ns
B x C	Ns
A x B x C	Ns

Ns = Not significant*; ** = significant at 1% probability level of the F-test.*

4. DISCUSSION

Cowpea (*Vigna unguiculata* L.) seed is the most popular preferred protein diet in Nigeria, but is also the most suitable medium for the reproduction of the cowpea weevil, *Callosobruchus maculatus* (Fabricius) Coleoptera: Chrysomelidae). It inflicts serious damage, resulting in huge losses (10 - 85%), thus, there has been several attempts for its control ranging from synthetic insecticides and bio-products (3 refs). The present study investigated the effects of four plant products ((*Acacia nilotica* L. Wild. Ex Del.; *Capsicum frutescens* L.; *Zingiber officinale* Rosc., *Khaya senegalensis* (Desv.) A. Juss) along with synthetic insecticide (Primiphos methyl 2% Dust), three methods of application (slurry, soak and dust), and five doses (0.5, 1.0, 1.5, 2.0 and 2.5 g/100 g of cowpea). The results expressed significant differences in the single factor and interactive effects of plant products, method of application and dosage on oviposition, adult emergence, mortality and weight loss in cowpea seeds. The result on plant products treatments expressed that none of the plant products showed higher effects than the synthetic insecticide, Pirimiphos methyl. Earlier studies had similarly reported superior effects of the synthetic insecticides, pirimiphos methyl in reducing progeny emergence, reducing cowpea seed weight loss and damage and inflicting higher mortality, when included as a reference (standard) to plant products (Bamaiyi et al., 2007; Swella and Mushobozy, 2007; Yusuf et al., 2011; Ekeh et al., 2013; Ogbonna et al., 2016). In the present study, however *Capsicum frutescence* was the most effective out of the four assessed plant products. It registered significantly fewer eggs and emerged adult beetles, while offspring mortality was higher and weight loss in cowpea seed lower. Thus, the relative order of efficacy ranking of the tested plant products on oviposition, adult emergence and mortality was consistently *Capsicum frutescens* > *Zingiber officinale* > *Khaya senegalensis* > *Acacia nilotica*. In contrast, cowpea weight loss in *Acacia nilotica* was significantly lower compared to *Zingiber officinale* and *Khaya senegalensis*. Earlier study by Yusuf et al. (2011) also rated the efficacy of *Capsicum frutescens* higher than *Acacia nilotica* in reducing cowpea seed weight loss and seed damage. Thus, *Capsicum frutescens* gave the best effect among plant products. There are five *Capsicum* species i.e. *Capsicum pubescens*, *Capsicum baccatum*, *Capsicum annuum*, *Capsicum frutescens* and *Capsicum chinense* (Biswas et al., 2011); and Capsaicinoid is phenolic pungent compounds found in *Capsicum* fruits and contribute to 90% of pungency of pepper fruits. The chemical group of alkaloid compounds called capsaicinoids (capsaicin, dihydrocapsaicin and nonivamide (pelargonic acid vanillylamide), are responsible for the pungency of the *Capsicum* species (Wesołowska et al., 2011). The analysis revealed that the major components of the extracts are capsaicin, dihydrocapsaicin and nonivamide (pelargonic acid vanillylamide). Capsaicin (8-methyl-*N*-vanillyl-6-nonenamide) accounts for about 50 to 70% of the total capsaicinoids, which through its hot sensation is believed to exert detrimental effects towards insect pests (Johnson et al., 2009; Oni et al., 2011). Other bite-contributing components are dihydrocapsaicin, nordihydrocapsaicin, homocapsaicin and homodihydrocapsaicin (Vinayaka et al., 2010).

Results of the present study further showed that Dust was the most effective among methods of application treatments, with significantly fewer egg-count and emerged adults, while weight loss was lower and mortality higher, and that Soak was also, more effective than Slurry by these parameters. This might be due to effects of the added water in reduction of the effectiveness of the plant products through hydrolysis, smoothening of the seed surface and softening of both testa and cotyledon of the cowpea seed, which might have enhanced preference for oviposition and easy penetration and development of the larvae. *C. maculatus* was reported to show preferences for smooth-seeded cowpea, and soft testa and cotyledon for oviposition and development (2 refs).

Result of the present study in respect of dosages indicated decreased oviposition, adult emergence and weight loss in cowpea seed, while mortality increased with each successive increase in dosage. Previous studies with varied quantities of plant product powders ranging 0.2 - 7.5 g, and cowpea from 20 - 100 g, revealed that increasing the dosages resulted in better protection in respect of oviposition, emerged adults by *C. maculatus* and cowpea seed weight loss (Oni, 2010; Yusuf et al., 2011; Ekeh et al., 2013; Abdullahi et al., 2014; Ekeh et al., 2015). However, since the highest quantity gave the best result in both present and present studies, it is apparent that the optimum dosage limit is yet to be reached.

The present study also revealed highly significant effects of the second order interactions of product x method, plant product x dosage and method x dosage and third order interactions of plant product x method x dosage on some measured *C. maculatus* and cowpea indices. In general, Primiphos methyl gave higher effects in terms of oviposition than all plant products, but *Capsicum frutescens* gave comparable effects as dust on adult emergence and weight loss, and exhibited higher effect in terms of mortality than Primiphos methyl when applied as slurry or soak. Furthermore, *Capsicum frutescens*, when applied as dust, at dosage of 2.5 g was as effective as lower dosages (0.5 or 1.5 g) of the synthetic insecticide, Primiphos methyl as dust. Overall, therefore *Capsicum frutescence* in dust form at dosage of 2.5 g was the most effective treatment combination, and was as effective as lower dosages (0.5 or 1.5 g) of the synthetic insecticide, Primiphos methyl as dust; it is recommended for the control of *C. maculatus* infestation in cowpea storage.

5. SUMMARY AND CONCLUSION

The interactive effects of plant product x method on the four measured *C. maculatus* and cowpea indices was also highly significant (P<0.01). Primiphos methyl gave higher effect in terms of oviposition than all plant products, but *Capsicum frutescens* gave comparable effects as dust on adult emergence and weight loss, and exhibited higher effect in terms of mortality than Primiphos methyl when applied as slurry or soak. Interaction of plant product x dosage was also significant on oviposition, adult emergence and mortality and regression expressed that effects ranged 98.24 - 99.85%, 96.45 - 99.76% and 85.56 - 99.85%; while maximum observed oviposition, adult emergence and mortality figures significantly varied from 9.14 - 85.68 eggs, 4.22 - 40.27 beetles, 3.24 - 31.19% among dosages of plant products, respectively. Results consistently show that irrespective of plant product, number of eggs oviposited by *C. maculatus* and adult emergence was relatively lower, while mortality increased with dosage was higher in Primiphos methyl, followed by *Capsicum frutescence*. The regression coefficient indicated that each gram increase in dosage caused reduction in oviposition and adult emergence by 1.44 - 4.58 eggs and 0.76 - 3.08 beetles, while mortality increased by 0.54 - 2.43%. These represent proportionate equivalent decrease in the total eggs oviposited in Primiphos methyl, *Capsicum frutescence*, *Zingiber officinale*, *Khaya senegalensis* and *Acacia nilotica* by 15.75, 6.24, 2.30, 3.32 and 5.35%, and number of emerged adults in the listed plant products by 18.01, 12.43, 5.54, 5.29 and 8.53%, respectively. Conversely, there was concomitant increase in mortality of the total number *C. maculatus* killed in the aforementioned respective plant products, by 16.67, 11.43, 7.53, 7.79 and 7.80%, respectively. The interaction of method x dosage was significant (P<0.01) and the effects on oviposition and adult emergence varied from 98.65 - 99.79% and 98.02 - 98.92%, respectively. Oviposition and adult emergence were relatively lower in Dust than Soak or Slurry methods, which registered maximum of 23.47, 70.0 and 77.6 eggs, and 11.15, 32.11 and 35.90 beetles, respectively. The b-value expressed that the number of eggs laid and emerged adults decreased by 1.83 - 3.86 eggs and 1.31 - 2.68 beetles per every gram increase in dosage, equivalent to 7.80, 3.46 and 4.97% of the total oviposited eggs, and 11.75, 5.01 and 7.47% of the total emerged adults, in Dust, Soak and Slurry methods, respectively. Overall result of the present study revealed that Primiphos methyl when used as dust at dosage 2.0 or 2.5 g gave the best effect on oviposition, adult emergence and mortality. However, the most effective plant product was *Capsicum frutescens* as dust at dosage of 2.5 g, and was comparable in efficacy to lower dosages (0.5 or 1.5 g) of Primiphos methyl as dust.

In conclusion, therefore *Capsicum frutescens*, when applied as dust, at dosage of 2.5g was as effective as lower dosages (0.5 or 1.5 g) of the synthetic insecticide, Primiphos methyl as dust. Primiphos methyl gave higher effect in terms of oviposition than all plant products, but *Capsicum frutescens* gave comparable effects as dust on adult emergence and weight loss, and exhibited higher effect in terms of mortality than Primiphos methyl when applied as slurry or soak.

6. RECOMMENDATION

The foregoing results expressed significant differences in the single factor and interactive effects of plant products, method of application and dosage on oviposition, adult emergence, mortality and weight loss in cowpea seeds. *Capsicum frutescens* was the most effective among the tested plant products, while dust was the best method of application, and 2.5 g was the most effective dosage on adult emergence, mortality and weight loss. Overall, result revealed that *Capsicum frutescence* in dust form at dosage of 2.5 g was the most effective treatment combination, and was as effective as lower dosages (0.5 or 1.5 g) of the synthetic insecticide, Primiphos methyl as dust. Similarly, *Capsicum frutescence* gave comparable effects as dust on adult emergence and weight loss, and exhibited higher effect in terms of mortality than Primiphos methyl when applied as slurry or soak. It is apparent that *Capsicum frutescence* using dust application method at dosage of 2.5 g was the most effective treatment combination; therefore, it is recommended for the control of *C. maculatus* infestation in cowpea storage. However, since the dust form of all plant products was the most effective, but the effects dosage continuously increased, suggesting that the limit for dosage had not been reached, further work with higher dosages is hereby recommended.

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