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DOI: <http://dx.doi.org/10.4314/acsj.v25i1.5>



## ESSENTIAL OIL EXTRACT FROM *MORINGA OLEIFERA* ROOTS AS COWPEA SEED PROTECTANT AGAINST COWPEA BEETLE

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(Received 27 October, 2015; accepted 13 February, 2017)

### ABSTRACT

Cowpea (*Vigna unguiculata* (L.) Walpers), is an important food legume in drier regions of the world, which is threatened by cowpea weevil (*Callosobruchus maculatus*), which is a cosmopolitan field-to-store pest of cowpea with infestation usually starting from the field. Cowpea weevil causes quantitative and qualitative losses, manifested by seed perforation, reductions in seed weight, reduced income to households, reduced market value and low seed germination. The objective of this study was to evaluate the efficacy of *Moringa oleifera* (Lam.) roots essential oil extract on the survival of *Callosobruchus maculatus*. Behaviour of Hexane extract of powdered *Moringa oleifera* roots was obtained by the Soxhlet extraction method. Moringa roots oil extract was applied at dosages of 0.5 l, 1.0 l, 1.5 and 2.0 ml per 20.0 g of Ife Brown Peduncle cowpea (susceptible variety) seeds. Dichlorvos (DDVP: 2,2-dichlorovinyl dimethyl phosphate) was included as a check. It was applied at dosage of 2.0 ml per 20.0 g cowpea seeds. Moringa roots oil extract at 2.0 ml per 20 g cowpea seeds resulted in significantly ( $P < 0.05$ ) higher mortality of 98.1% compared with Dichlorvos (89.9%). Also, 2.0 ml of root extract applied on the dorsum of adult insects (topical application) resulted in the highest mortality (100%) at 72 hours after application, compared with Dichlorvos (99.2%). There were significant reductions in the number of eggs laid in the order of 7.5 (0.5 ml), 8.0 (1.0 ml), 11.8 (1.5 ml) and 6.5 (2.0 ml); compared with Dichlorvos (20.8). Significantly fewer adults emerged from 0.5 ml (20.3), 1.0 ml (15.5), 1.5 ml (11.8) and 2.0 ml (9.0) root extracts than with Dichlorvos (37.0). Similarly, oviposition, contact toxicity and mortality were dose dependent; and higher concentrations significantly protected cowpea seeds against damage by *C. maculatus*. There was no significant difference in seed weight loss. Also, cowpea seeds coated with moringa roots oil extract germinated normally. The roots oil extract at 2.0 ml per 20.0 g cowpea seeds reduced damage by *C. maculatus* and was effective in controlling *C. maculatus* infestation on stored cowpea seeds.

**Key Words:** 2,2-dichlorovinyl dimethyl phosphate, contact toxicity, *Moringa oleifera*, oviposition, *Vigna unguiculata*

### RÉSUMÉ

L'efficacité d'extrait d'huile essentielle de racines de *Moringa oleifera* sur la mortalité, la toxicité de contact, l'oviposition et l'émergence des adultes de *Callosobruchus maculatus* a été menée au Département de la protection des cultures et de biologie environnementale, Université d'Ibadan au Nigeria. L'extrait à l'hexane de poudre de racines de *Moringa oleifera* a été obtenu par la méthode d'extraire soxhlet. L'extrait de l'huile a été appliqué à des dosages de 0,5 ml, 1,0 ml, et 2,0 ml par 20,0g des graines de niébé 'Ife Brown' Peduncleo. (en variété sensible). Dichlorvos (DDVP: 2,2-dichlorovinyl, phosphate de diméthyle) a été inclus comme un cheque. Il a été appliqué à la dose de 2,0ml par 20,0 g de graines de niébé. Le 'damage' de graines de niébé, la perte de poids et la viabilité

de niébé revêtus étaient également évalués. L'extrait d'huile de racines a 2,0 ml per 20 g de graines de niébé a pour résultat, de manière significative ( $P < 0,05$ ), une mortalité plus élevée de 98,1% par rapport aux dichlorvos (89,9%). De plus, 2,0 ml d'extrait de racine utilisé sur les insectes adultes, a pour résultat ( $P < 0,05$ ), la mortalité la plus élevée, 100% à 72 heures après l'application par rapport à Dichlorvos (99,2%). Il y avait des réductions importantes dans le nombre d'œufs pondus 7,5 (0,5ml), 8,0 (1,0ml), 11,8 (1,5 ml) et 6,5 (2,0 ml) par rapport à dichlorvos (20,8) à  $P < 0,05$ . Un petit nombre d'adultes ont émergé de 0,5 ml (20,3), 1,0 ml (15,5), 1,5 ml (11,8) et 2,0 ml (9,0) d'extraits de racine par rapport aux dichlorvos (37,0). Sommairement, l'oviposition, la toxicité de contact et la mortalité étaient dépendants du dosage. Aussi, des concentrations, les plus élevées, ont protégé les graines de niébé de manière significative contre les dommages par *C. maculatus*. Il n'y avait pas de différence majeure à propos de la perte de poids en pourcentage. Également, des graines de niébé revêtus d'extrait d'huile de racine de moringa n'ont pas arrêté le potentiel des graines de germiner. L'extrait d'huile de racine de moringa a 2,0 ml/20,0g de graines de niébé a réduit des dommages causés par *C. maculatus* et c'était efficace dans le contrôle de l'infestation de *C. maculatus* sur les semences de niébé stockées.

**Mots Clés:** 2,2-dichlorovinyl diméthyle phosphate, contact toxicity, *Moringa oleifera*, oviposition, *Vigna unguiculata*

## INTRODUCTION

Cowpea (*Vigna unguiculata* (L.) Walpers), is a key food legume and an essential component of cropping systems in drier regions of the world (Fatokun *et al.*, 2002). The weevil (*Callosobruchus maculatus*) is a cosmopolitan field-to-store pest of cowpea. The infestation usually starts from the field and continues in the store. *Callosobruchus maculatus* causes quantitative and qualitative losses manifested by seed perforation, reductions in seed weight, reduced income to producers, reduced market value and poor seed germination. These losses constitute a major threat to food security and availability in Nigeria (Ofuya, 2001). Losses often range between 40 and 100% in unprotected cowpea (Akinkulere *et al.*, 2006; Madamba *et al.*, 2006).

Over the years, especially in Nigeria and other parts of the world, successful management of this insect pest, both on the field and in storage, has been dominated by synthetic chemical control methods such as use of pirimiphos methyl, fenitrothion, methyl bromide and phosphine fumigant (Jackai and Daoust, 1986). Due to the high prices of synthetic pesticides, farmers and traders in most Nigerian markets indiscriminately apply cheap pesticides of high mammalian toxicity, to cowpea seeds; thus, exposing unsuspecting buyers to chronic toxicity.

Consequently, there is an increasing interest in the use of pesticides of plant origin, in order to reduce environmental pollution, contamination of food and other associated problems. Previous works (Akinkulere *et al.*, 2006; Mbailo *et al.*, 2006; Akinkulere, 2007; Echereobia *et al.*, 2010; Panchal *et al.*, 2011) demonstrated the efficacy of different plant oils, plant extracts and dry powders of different plant parts, as protectants against storage pests.

Moringa (*Moringa oleifera*), which is one of such plants belongs to family Moringaceae. It is a multi purpose plant, cultivated in tropical regions. It is referred to as a "miracle tree" or a "wonder tree" of significant socio-economic importance because of its several nutritional, pharmacological (Fuglie, 2001), anti-hypertensive activity (Dangi *et al.*, 2002) and industrial applications (Foidl *et al.*, 2001). Many researchers have tested the efficacy of moringa leaf powder (Obopile *et al.*, 2012; Kayode and Olaniyi, 2014), seed powder (Obopile *et al.*, 2012; Kayode and Olaniyi 2014) and root powder (Obopile *et al.*, 2012; Race *et al.*, 2012) as protectants against *C. maculatus*, on stored cowpea seeds. However, none of the available research works on pest control ability of *M. oleifera* has ever explored the possibility of its root essential oil as a protectant against *C. maculatus* infestation on stored cowpea seeds. Several metabolites have

been identified in *Moringa* roots (Paul and Didia, 2012). Pterygospermin inhibits the growth of many bacteria and fungi. It also contains alkaloids; moringine, moringinine and spirochin with traces of an essential oil which has a pungent smell. Spirochin causes nerve paralysis in organisms. Therefore, the active principles in *Moringa* root oil extract could be explored in developing an Integrated Pest Management (IPM) strategy for controlling *C. maculatus* in stored cowpea seeds (Ojiako *et al.*, 2013). This study was aimed at assessing the efficacy of *Moringa oleifera* root essential oil extract against the cowpea beetle, *C. maculatus*.

## MATERIALS AND METHODS

**Rearing of the beetle.** Stock culture of *C. maculatus* was raised on Ife-Brown Peduncle Cowpea (Ife BPC), obtained from the Institute of Agricultural Research and Training (IAR&T) Ibadan, Nigeria. About 100 unsexed adults were infested on 200 g of clean Ife BPC, inside each of four kliner jars. The kliner jars were covered with lids having muslin cloth, to allow aeration and prevent pests from escaping. The beetles were allowed to mate and lay eggs for seven days, after which they were removed and seeds were watched for emergence of  $F_1$  generation (teneral adults). Culture was maintained at  $29 \pm 5$  °C and  $72 \pm 6\%$  relative humidity

**Collection and extraction of essential oils.** Roots of *Moringa oleifera* collected from the Agronomy garden, Department of Agronomy and Forestry garden, Department of Forest Resources Management, University of Ibadan in Nigeria were placed inside plastic buckets. The roots were chopped and washed thoroughly with tap-water. They were air-dried in the Entomology Research laboratory at the Department of Crop Protection and Environmental Biology University of Ibadan in Nigeria under ambient temperature of  $29 \pm 5$  °C and relative humidity of  $72 \pm 6\%$ . Dried roots were pulverised into powder, using a milling

machine with revolution at 1425 Hz (Hertz) per minute. Thirty grammes of dried *M. oleifera* roots were weighed into a thimble and placed over a round bottom flask containing 300 ml of 98% technical grade of n-hexane. The extraction process involved the condensation of n-hexane vapour over the powdered samples in the thimble. The extract was used to treat seeds at the various concentrations (0.5, 1.0, 1.5 and 2.0 ml per 20.0 g cowpea seeds).

A synthetic insecticide, Dichlorvos (DDVP: 2,2-dichlorovinyl dimethyl phosphate (Nopest); molar mass:  $220.98 \text{ g mol}^{-1}$  and boiling point:  $74.1$  °C) was included in the experiments as a check at 2.0 ml per 20.0 g of cowpea seeds.

**Number of eggs laid.** Twenty grammes of seeds treated, with different concentrations of essential oils at (0.5, 1.0, 1.5 and 2.0 ml) and 2.0 ml of Dichlorvos, were infested with five pairs of teneral adults, and the total number of eggs laid were counted daily until all adults were dead. The seeds were kept to observe the emergence of teneral adults. Data on number of eggs laid and total number of adult emerged were collected.

**Fumigant and contact toxicity bioassays.** Twenty grammes of clean cowpea seeds were coated with different concentrations of *Moringa* roots oil extract, at 0.5, 1.0, 1.5 and 2.0 ml and Dichlorvos. Five pairs of teneral adults were used to infest treated seeds. The jars were covered with an airtight lid, and the experiment was replicated four times. For contact toxicity bioassay, different concentrations of *moringa* roots oil extract at 0.5, 1.0, 1.5 and 2.0 ml; and 2.0 ml of Dichlorvos were applied on the dorsal thoracic region (notum) of five pairs of adult male and female beetles inside petri-dish using Hamilton syringe (Sigma<sup>®</sup>, USA, Model 705 N). Data on daily mortality were taken at 24, 48 and 72 hours after oil application. Percentage mortality was expressed as:

$$\frac{\text{Number of dead insects}}{\text{Total number of insects introduced}} \times 100$$

Data on percentage adult mortality were corrected using Abbott's (1925) formula:

$$P_t = \frac{(P_o - P_c)}{(100 - P_c)} \times 100$$

Where  $P_t$  = Corrected mortality;  $P_o$  = Observed mortality on treatment;  $P_c$  = Control mortality.

**Seed damage assessment.** Five pairs of general adults were introduced into 20 g of treated and untreated cowpea seeds.

Percentage weight loss was determined at 30 and 60 days after Infestation using the formula:

$$\text{Weight loss (\%)} = \frac{\text{Initial weight} - \text{Final weight}}{\text{Initial weight}} \times 100$$

Percentage seed damaged was calculated as follows according to Adedire and Ajayi (1996)

$$\text{Seed damage (\%)} = \frac{\text{Weight of damaged seeds}}{\text{Total weight of seeds introduced in an arena}} \times 100$$

Moisture content was corrected according to Odeyemi and Daramola (2000):

$$\text{Moisture content (\%)} = \frac{\text{(Average weight)}}{\text{(Initial weight)}} \times 100$$

**Seed viability test.** Twenty five cowpea seeds from each treated and untreated control were placed inside a 9 cm–diameter petri dish lined with Whatman's filter paper. Seeds were moistened with water daily and watched for germination. At 7 days after the experiment set up, percentage seed germination was calculated as:

$$\text{Seed germination (\%)} = \frac{\text{(Number of germinated seeds)}}{\text{(Total number of seeds introduced)}} \times 100$$

**Statistical analyses.** All data were analysed using analysis of variance (ANOVA) GENSTAT software (Little and Hills, 1978). Where there were significant differences, means were separated using least significant difference (LSD) at 0.05 level of significance.

## RESULTS

**Oviposition and adult emergence.** Table 1 shows the number of eggs laid and adult *C. maculatus* that emerged from the different treatments. The highest number of eggs ( $66.8 \pm 15.4$ ) was laid on control (untreated) seeds. The least eggs ( $6.5 \pm 2.4$ ) were laid on cowpea seeds treated with 2.0 ml oil extract; however, it was not significantly different from other rates of oil extracts.

The highest number of adults ( $152.3 \pm 18.0$ ) emerged from untreated seeds (Table 1). The least number of adults ( $9.0 \pm 3.4$ ) emerged from seeds coated with 2.0 ml oil extract; however, it was not significantly different from other doses of oil extracts. Seeds treated with Dichlorvos recorded  $37.0 \pm 5.7$  adults and was significantly higher than adults that emerged from the oil extracts.

TABLE 1. Efficacy of Moringa roots oil extracts and Dichlorvos on *Callosobruchus maculatus* egg laying and adult emergence

Treatment	Eggs laid	Emerged adults
Dichlorvos (2.0 ml)	20.8	37.0
0.5 ml root extract	7.5	20.3
1.0 ml root extract	8.0	15.5
1.5 ml root extract	11.8	11.8
2.0 ml root extract	6.5	9.0
Control	66.8	152.3
LSD (0.05)	11.9	12.6

**Fumigant toxicity.** Data for fumigant toxicity of Moringa root oil extract against adults of *C. maculatus* are presented in Table 2. At 24 hr after exposure to the treatments, mortality was highest on adults in 2.0 ml oil extract (88.4%); but it was not significantly different ( $P>0.05$ ) from mortalities on 1.0 ml (82.9%) and 0.5 ml (80.6%). In Dichlorvos treated seeds, 66.7% mortality was recorded, but was not significantly different from 1.5 ml (73.4%).

The highest adult mortality was recorded on seeds treated with 2.0ml (96.3%); but it was not significantly different from adults on Dichlorvos (86.6%), 0.5 ml (87.9%), 1.0 ml (91.2%) and 1.5 ml (84.4%) at 48hr after exposure (Table 2).

At 72 hr after exposure, a similar trend was observed like at 48 hr after exposure (Table 2). The highest adult mortality was recorded on seeds treated with 2.0 ml (98.1%); but mortality was not significantly different from adults on Dichlorvos (89.9%), and other dosages of the oil. The overall mortality increased with increase in time of exposure across all the treatments (Table 2).

**Contact toxicity of treated cowpea seeds.** Contact toxicity of Moringa root extracts, against adult *C. maculatus* at 24, 48 and 72 hours after exposure is presented in Table 3. Mortality increased with increase in hours of

exposure and oil concentrations. Mortality was above 50% in all the treatments, apart from the control. At 24 hr after application of treatments, the highest adult mortality was recorded from 2.0 ml (95.0%); but was not significantly different ( $P<0.05$ ) from mortality recorded from Dichlorvos (89.7%). No adult mortality was recorded from control seeds. Significant mortality was also recorded from 0.5 ml (72.5%), 1.0 ml (77.5%) and 1.5 ml (78.8%).

Also, at 48 hr, 2.0 ml had the highest mortality of (97.5%), but was not significantly different from Dichlorvos (98.3%), 0.5 ml (79.6%), 1.0 ml (79.9%), 1.5 ml (84.8%). No adult mortality was recorded from untreated seeds (0.0%).

At 72 hr after application, all the insects were dead (100%) on the seeds treated with 2.0 ml; however, the effect was not significant except when compared with the untreated control, where no adult mortality was recorded. From Dichlorvos, there was 99.2% mortality, 0.5 ml (91.0%), 1.0 ml (92.2%), 0.5 ml (91.0%) mortalities and control had 0.0% mortality (Table 3).

**Seed damage and weight loss.** At 30 days after infestation, the lowest seed damaged (5.5%) was recorded in 2.0 ml treated seeds (Table 4). However, this was not significantly different from 1.5 ml (8.0%), Dichlorvos

TABLE 2. Fumigant toxicity of different concentrations of moringa roots oil extract and Dichlorvos on *Callosobruchus maculatus*

Treatments (ml)	Percentage mortality		
	24 hours	48 hours	72 hours
Dichlorvos (2.0 ml)	66.7	86.6	89.9
0.5 root extract	80.6	87.9	92.7
1.0 root extract	82.9	91.2	94.3
1.5 root extract	73.4	84.4	94.6
2.0 root extract	88.4	96.3	98.1
Control	0.0	50.7	58.6
LSD (0.05)	12.4	26.3	20.3

TABLE 3. Contact toxicity of different concentrations of moringa roots oil extract and Dichlorvos on *Callosobruchus maculatus*

Treatments	Percentage mortality		
	24 hours	48 hours	72 hours
Dichlorvos (2.0 ml)	89.7	98.3	99.2
0.5 ml	72.5	79.6	91.0
1.0 root extract	77.5	79.9	92.2
1.5 root extract	78.8	84.8	91.0
2.0 root extract	95.0	97.5	100
Control	0.0	50.7	58.6
LSD (0.05)	14.9	24.8	14.0

TABLE 4. Percentage seed damaged and weight losses in infested cowpea seeds treated with different concentrations of Moringa roots essential oil

Treatments	% seed damaged at 30 DAI	% seed damaged at 60 DAI	% weight loss at 30 DAI	% weight loss at 60 DAI
Dichlorvos (2.0 ml)	8.1	8.7	5.2	9.5
0.5 ml root extract	9.1	9.4	7.5	10.6
1.0ml root extract	8.3	10.6	7.0	8.7
1.5 ml root extract	8.0	8.2	6.6	7.3
2.0 ml root extract	5.5	7.6	5.1	6.0
Control	15.4	27.2	10.0	14.3
LSD (0.05)	3.6	2.7	4.0	7.2

(8.1%), 1.0 ml (8.3%); but it was significantly lower than 0.5 ml (9.1%). The highest percentage seed damaged was recorded from the untreated (control) seeds (15%).

Similarly, at 60 DAI, the lowest seed damaged, 7.6% was recorded from 2.0 ml treated seeds; though the effect was not significantly different from Dichlorvos (8.7%) (Table 4). The highest percentage seed damaged, 27.2% was recorded from untreated seeds. A damage of 10.6% was recorded from seeds treated with 1.0 ml at 60 DAI.

At 30 DAI, the lowest seed weight loss of 5.1% was recorded from seeds treated with 2.0 ml, but the effect was not significantly different ( $P > 0.05$ ) from Dichlorvos (5.2%) (Table 4). The highest weight loss of 10% was recorded from the untreated seeds 30 DAI. A

similar trend in seed weight loss was also obtained at 60 DAI in which 2.0 ml had the least percentage loss of 6.0% (Table 4). This was not significantly different ( $P > 0.05$ ) from weight losses recorded from Dichlorvos (9.5%), 0.5 ml (10.6%), 1.0 ml (8.7%) and 1.5 ml (7.3 %). The highest percentage seed weight loss of 14.3% was obtained from the untreated seeds.

**Seed viability.** The different concentrations of Moringa root extracts did not adversely affect seed viability (Table 5). Total (100%) germination of seeds was recorded from untreated seeds; but was not significantly different ( $P > 0.05$ ) from 0.5 ml (96%), 1.0 ml (98%), 1.5 ml (98%) and 2.0 ml (99%). A seed viability of 92% was recorded from

TABLE 5. Seed viability of cowpea seeds treated with different concentrations of Moringa roots oil extracts

Treatments	Seed viability (%)
Dichlorvos (2.0 ml)	92.0
0.5 ml root extract	96.0
1.0 ml root extract	98.0
1.5 ml root extract	98.0
2.0 ml root extract	99.0
Control	100.0
LSD (0.05)	7.2

Dichlorvos treated seeds and was significantly lower than all the other treatments ( $P < 0.05$ ).

## DISCUSSION

**Oviposition and adult emergence.** The marked differences observed on the emergence of adult *C. maculatus* reared on treated and untreated cowpea seeds in Table 1 indicate that oil extract from Moringa roots had marked effects on the developmental stages, which in turn affected emergence. All concentrations of Moringa roots oil extract reduced the emergence of teneral adult, suggesting that the treatments impaired the developmental stages of *C. maculatus*. The reduction in number of eggs laid could be due to the pungent smell present in the oil, which may have deterred the insect from laying eggs because the essential oil of moringa roots have been reported to have a pungent smell (Paul and Didia, 2012). Consequently, this may have been responsible for the inability of most of the adult insects to emerge as the application of oils were found to disrupt growth and reduced larval survival as well as disruption of life cycle of the pest.

Arannilewa *et al.* (2006) reported that the application of oil extract covered the outer layer (testa) of the seeds, which serve as food poison to the adult insects; while some of the oil applied penetrated into the endosperm and germ layer thereby suppressing oviposition and larval development. Elumalai *et al.* (2010) and

Sadeghi *et al.* (2006) also demonstrated the efficacy of neem oil and plant lectins against target pests, respectively. Several researchers (Kayode and Olaniyi, 2014; Ileke and Oni, 2011; Udo, 2011; Akinneye and Ogungbite, 2013) demonstrated the efficacy of extracts and powders plants: *Azadirachta indica*, *Zanthoxylum zanthoxyloides*, *A. occidentale* on target pest.

In contrast, Dichlorvos considerably reduced the number of adult emergence; this could be due to the ability of the synthetic pesticide, Dichlorvos to impede the functioning of central nervous system thereby disrupting the growth and reduced larval survival.

**Contact toxicity and fumigant action.** Significant differences were observed in the mortality of adult *C. maculatus* as oil concentration and exposure time increased. Also, mortality and toxicity were dose dependent and as the concentration level increased, the mortality and toxicity increased in level of exposure (Tables 2 and 3). Moringa roots oil extract (MROE) and synthetic pesticide (Dichlorvos) were toxic to *C. maculatus*, and the toxicity was dose dependent.

The resultant high mortalities and toxicities of adult *C. maculatus* could be due to high toxic effect of the roots oil extract. Paul and Didia (2012) documented the active principles in roots and the following constituents; pterygostermin, alkaloids, traces of essential oil, phytosterol, waxes and resins, were found. Pterygostermin have inhibitory effects on some bacteria and fungi. Toxicity of the essential oil may have led to inability of the pest to feed on the coated cowpea seed due to starvation, choking and consequently death of the insects (Ebadollahi, 2013).

The fumigant action of *Eucalyptus intertexta*, *E. sargentii* and *E. camaldulensis* essential oils against *C. maculatus* Fab., *Sitophilus oryzae* (L.) and *Tribolium castaneum* (Herbst) were investigated by Negahban and Moharrimpour (2007). The

three essential oils had fumigant toxicities against the insect pests. Essential oil vapours from three plants, *Lavandula hybrida*, *Rosmarinus officinalis* and *Eucalyptus globulus*, were toxic to all the immature stages, larvae and pupae, of *Acanthoscelides obtectus* (Papachristes and Stamopoulos, 2002).

The effectiveness of oil extract from *M. oleifera* roots against *C. maculatus* could be due to its pungency (Panchal *et al.*, 2011). *Moringa oleifera* root powders caused reduction in seed damage on cowpea infested with *C. maculatus* (Race *et al.*, 2012). Also, *Moringa oleifera* root extracts recorded 58.87% weevil perforation index on stored cowpea grains (Ojiako *et al.*, 2013). Adenekan *et al.* (2013) reported that *Moringa oleifera* powders from leaves, stem bark, roots and flowers had insecticidal effects on oviposition, eclosion and development of *C. maculatus* on cowpea seeds with flower powders having significantly higher effects compared with other plant parts.

**Seed damage and weight loss.** The number of seeds damaged by all treatments increased with duration of the study period (Table 4). This may be attributed to increase in the total number of *C. maculatus* and this may have led to degradation of the effectiveness of the Moringa roots oil extract, which served as protectants with time. Ogendo *et al.* (2004), similarly reported that the use of natural plant powders such as *Lantana camara* and *Tephrosia vogelii*, significantly reduce grain damaged in stored maize. Cowpea seeds, coated with higher dosage of Moringa roots oil extract suffers significant reduction in seed damage and lower weight loss possibly due to reduced oviposition and number of eggs that hatched; therefore, reducing larval feeding, this consequently lowered the percentages of seeds damaged and seed weight losses. The root extract of 2.0 ml compared favourably with the synthetic, Dichlorvos (Table 4), and could

be a suitable replacement if cowpea seeds will not be stored for a long period of time.

The efficacies of treatments (Moringa roots oil extract and dichlorvos) varied, depending on the doses and duration of exposure. The current result agrees with previous researchers (Adedire and Akinneye, 2004; Mbailo *et al.*, 2006), who showed that powder and ethanolic extracts of tree marigold, *Tithonia diversifolia*, seed oils from *Azadiracta indica*, *Ricinus communis*, *Thevetia nerifolia*, *Balanites egyptiaca*, *Moringa oleifera* and *Khaya senegalensis* protected the stored cowpea seeds against *Callosobruchus maculatus* infestation.

## CONCLUSION

All the concentrations of Moringa roots oil extract reduce egg laying, causing high mortalities of adults in contact and fumigant tests, reduction in adult emergence and seed damage. It is noteworthy that Moringa oil extract at 2.0 ml 20 g<sup>-1</sup> seed performs similar to the synthetic pesticide: dichlorvos, thus have a great potential to protect cowpea seeds in storage against *C. maculatus* infestation if timely applications are made. Currently cowpea varieties with relative resistance to *C. maculatus* have been identified. These varieties can be planted by farmers to reduce damage caused by *C. maculatus* infestation both on the field and in store and when infestation is high they can be treated with oil extract from moringa roots thus reducing reliance on synthetic pesticide. Farmers may consider protecting cowpea seeds with moringa root extracts to reduce *C. maculatus* infestation and preserve seeds for the next cropping season. Thus, *Moringa oleifera* roots oil extract can be incorporated into a sustainable pest management programme for the control of stored product insect pests such as *Callosobruchus maculatus* on stored cowpea seeds.



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