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Comparative efficacy of moringa, neem and lemon grass leaf powders in the control of bean beetle (*Callosobruchus maculatus* Fab.) infesting cowpea (*Vigna unguiculata* L. Walp)

L. Sanusi and N. D. Ibrahim

Department of Crop Science, Faculty of Agriculture, Usmanu Danfodiyo University, Sokoto

ABSTRACT

Insecticidal property of neem, moringa and lemon grass leaf powders were tested on *C. maculatus* feeding on stored cowpea in laboratory at 31.9^{O}C and relative humidity of 15.5 %. Eleven treatments were used, at three levels for each plant (1.0, 1.5 and 2.0/50g'. In addition, permethrin was used as positive control and untreated sample as negative control. The treatments were arranged in a completely randomized design (CRD) replicated three times. Four pairs of insects were introduced into each treatment and mortality was recorded for ten days. The mortality was 100% on the sixth day in seeds treated with moringa and neem leaf powders. Highest weight loss was in the negative control 1.18 g (2.37%) compared to 0.48g (0.95%) in the neem. Toxicity and feeding deterrent effect of all the three treatments were dose dependent, i.e. it increases as the dose increases. Therefore, moringa and neem leaf powders were effective protectants of *C. maculatus* against cowpea. It is recommended that 1g of the moringa and neem be used, i.e. 2.0 % per 50g of cowpea.

Keywords: Moringa; lemon grass; neem; bean beetle

INTRODUCTION

Hamzavi *et al*. (2022) reported that cowpea (*Vigna unguiculata* (L) Walpers, Fabaceae) is a common legume produced in tropical and subtropical zones of the world. It is an important edible legume crop in many parts of the world, especially in tropical and sub-tropical regions. It is used as human food due to its high protein content (Diouf, 2011). In addition to the high protein content of the cowpea, it also has high iron content but low in fats, in addition to its nitrogen fixation through its root nodules, and it grows well in poor soils with more than 85% sand and with less than 0.2% organic matter and low levels of phosphorous (Singh *et al.,* 2003).

Callosobruchus maculatus is an important field-to-store pest that causes close to 100% losses in stored produce (Tengey*et al*., 2023). Due to the short generation time, *C. maculatus* can infests up to 99% of stored beans in 6 months (Seck, 1993; Singh *et al*., 1978). In Nigeria, its availability continues to be hampered by storage and field pests, of which the cowpea seed bruchid *C. maculatus* (Fab.) is particularly problematic in stores, accounting for over 90% of the insect damage to stored cowpea. It is a cosmopolitan field-to-store pest ranked as the principal post-harvest pest of cowpea in the tropics (Caswell and

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Correspondence: sabongarindole@gmail.com
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Akibu, 1981). This pest is a major pest of stored cowpea, its eggs are laid on the legume grain surface, and hatching larvae feed on the inner endosperm, leaving a hole where adult insect emerge. It causes critical losses by decreasing grain weight, germination ability and nutritional value (Hamzavi *et al*., 2022). It causes substantial quantitative and qualitative losses manifested by seed perforation and reductions in weight, market value and germination ability of seeds (Oluwafemi, 2012).

The insect is a highly damaging and destructive pest of pulse seeds, which is widely distributed in tropical and subtropical areas (Hamzei *et al*., 2023). According to Adedire (2001), seed beetle *C. maculatus*, is unarguably a major insect pest militating against food availability and security. Interestingly, in its native environments of western Africa, *C. maculatus* produces two distinct life history morphs each year: a mobile morph with well-developed flight ability, which lays eggs directly on seed pods of growing plants during the rainy season, and a sedentary morph with reduced flight ability, which develops in seeds gathered and stored by humans (Prevett, 1961; Zannou *et al*., 2003). Zannou *et al*. (2003) observed that beetles survive in the tropical ecosystem for a long time and colonized the crops during the cowpea growing and flowering phases. Storage of cowpea seeds over long periods, especially at smallholder levels, is limited by bean beetle infestation. Huge losses of between 20 and 50% have been reported on stored cowpea due to attack by bean beetle, *C. maculatus* and sometimes the loss could be complete, accounting for 100% loss (Udo and Harry, 2013). Infestation of pods usually originate from the farm. Eggs are stuck on the outside of the pods by the female but if the pods are dehisced, the eggs are laid directly on the seed. Each female bruchid may lay up to 100 eggs (Beck and Blumer, 2007).

Management of cowpea seed storage relies heavily on the use of chemical insecticides. Ofuya (2001) reported that the major problems associated with the use of synthetic pesticides against the pest include the dangers to the user, exorbitant costs, pesticide resistance and food residue. Improper application of synthetic pesticides poses a threat to man and the environment, particularly among rural farmers in Africa. Currently, global research efforts now support the development of plant products with proven crop protection potentials (Aliyu *et al.*, 2011).

Chemicals, generally synthetic pesticides are extremely toxic and harmful to the environment. They are also harmful to animals and humans if they ingest such crops, causing immediate and acute and chronic problems. High cost of these chemicals also limits their availability to farmers, due to high rate of dollar-naira exchange. In order to reduce serious losses experienced during storage, various techniques and control methods have been developed and more are being developed. In view of the above, there is need to develop alternative sources for protecting grains from damage by insect pests. Plant extracts and plant dried- powders that have insecticidal potential and pose little or no threat to the ecosystem and the health of users have been locally employed with varying effectiveness in the management of crop pests such as neem oil, wood ash, lemon grass, ginger and garlic (Prowse *et al*., 2006). Botanicals are non-toxic to mammals; and environmentally, they do not persist because they rapidly breakdown and are metabolized easily by animals receiving sub-lethal doses (Ling, 2003). Laterza (2024) defined botanicals as substances derived from naturally occurring materials (i.e., plants, microorganisms and minerals) characterized by low environmental effects, rapid degradation, and low toxicity for humans and beneficial insects. Therefore, the use of natural products (bio-pesticides) which are cheap, safe, effective, less toxic to humans and environment, easy to adopt could serve as an alternative method of protecting stored cowpea against cowpea weevil, especially most of the small-scale farmers that have not adopted the use of chemicals due to some financial and technical reasons. The research was to study the effect of three leaf powders on mortality of *C. maculatus* feeding on cowpea alongside a synthetic.

i) *Azadirachta indica* A. Juss., commonly known as neem, possess biocidal activities such as insecticidal and fungicidal, and other pesticides have been recognized as one of the best bio-pesticides all over the world (Montes-Molina *et al*., 2008; Javed *et al*., 2008; Anjorin *et al*., 2008). Azadirachtin isolated from neem was found to have biocidal activity against nearly 400 species of pests (Montes-Molina *et al*., 2008). Neem-based pesticides with excellent insecticidal activity against locusts are labeled as ideal pesticides (Zhang *et al*., 2004). According to Vimala *et al*. (2010) the advantage of using neem leaf extract is that it is available throughout the year. Neem (leaf and seed) extracts have been found to have insecticidal properties and it is used as foliar spray.

ii) *Moringa oleifera* is a valuable bio-pesticidal plant (Mamun and Ahmed, 2011). It belongs to the single genus family-Moringaceae with 13 different species. The plant is widely cultivated in Africa. In Nigeria, *M. oleifera* is widely used traditionally for nutritional and medicinal purposes against various disease conditions (Furo and Ambali, 2012). It grows best in dry sandy soil; it tolerates poor soil including coastal areas and is drought resistant. Its various parts have been identified for antimicrobial activity (Dahot, 1998), analgesic activity (Marugandan *et al*., 2000), antihypertensive activity (Dangi *et al*., 2002) and insecticidal activity (Dahot 1998).

iii) Lemon grass (*Cymbopogon citratus*) is a perennial crop from grass family Poaceae with numerous industrial applications. Lemon grass is chiefly grown for its essential oil (EO) that has multiple medicinal (anticancer, analgesic and antimicrobial) and cosmetic usage (Chandrashekar and Prasanna, 2010; Ganjewala, 2009). In addition to these, lemongrass essential oil has extensive utilisation in the synthesis of eco-friendly pesticides because of its insect-repellent nature (Zheljazkov *et al.*, 2011; Ganjewala, 2009). Lemon grass EO is one from about 400-500 commercially produced EOs (Tisserand and Young, 2013). Lemongrass EO has rich spectra of compounds enriched with rigorous medicinal properties, e.g. antibacterial, antiviral, antifungal, antifungal, anticancer and antitumor (Sharma *et al.*, 2009). The objective of this was to assess the effectiveness of the three botanicals in the control of most damaging insect pes of cowpea, *C. maculatus*.

MATERIAL AND METHODS

Collection and Preparation of Plant Materials

Fresh, matured neem leaves were collected from the premises of Usmanu Danfodiyo University, Sokoto main campus at the hostel area for powder preparation. The leaves were air dried in shade until completely dried and pulverized into fine powder using mortar and pestle. The ground leaf powder was measured at 1.0, 1.5, and 2.0g mixed with 50g of cowpea seeds and replicated 3 times. Similarly, in order to prepare powder from the moringa leaves, 'moringa leaves were obtained from Dankure (local) market in Sokoto metropolis and treated as the neem leaves above. Also, fresh lemon grass leaves were sourced from a house in Sokoto metropolis. They were washed with tap water before shade-drying and pulverized into fine powder. The ground lemon grass leaves were also measured out in rates similar to neem and moringa with 50 g of cowpea.

Insect Culture

Insects were initially obtained from an infested cowpea obtained from Sokoto Central market and kept in the laboratory of Department of Crop Science, Faculty of Agriculture, Usmanu Danfodiyo University, Sokoto. Cultures of *C. maculatus* (F.) was setup by introducing newly emerged beetles in four glass jars, half filled with previously sterilized and conditioned cowpea seeds *V. unguiculata* L (Bt cowpea) and tightly covered with rubber band. The seeds were sterilized by keeping them in a refrigerator for two weeks, and thereafter kept in the laboratory for conditioning. The insects were reared for 20 days as parent stock to obtain the required number needed for the experiment. Sexes were identified according to Beck and Blumer (2007) using microscope and a brush. The most distinguishing characteristic is the coloration on the plate covering the end of the abdomen of insects. In the female, the plate is enlarged and darkly colored on both sides. In the male, the plate is smaller and lacks stripes**.**

Preparation of Cowpea Seeds

SAMPEA 20-T or Bt (*Bacillus thuringiensis*) cowpea seeds were sourced from Ahmadu Bello University (ABU) Zaria after ensuring they were not treated. The seeds were left to freeze for fourteen days to eliminate possible hidden infestation and developing stages of any insect pest (Udo, 2008). The seeds were air-dried in the laboratory for four hours prior to use to acclimatize them. Four pairs of freshly emerged adults were introduced into each treatment.

Experimental Design and Experiment

The experiment consisted of 11 treatments (3 levels each of neem, moringa and lemon grass leaves plus positive and negative controls) replicated three times. Each treatment contained 50 g of cowpea seeds. The 50 g seeds of cowpea were treated with 1.0, 1.5 and 2.0g of the treatments and permethrin at 1.5 g/50g of cowpea seeds as check. Four (4) pairs of male and female, *C. maculatus* were introduced into each of the plastic jars, which were covered using muslin cloth and tied with a rubber band to avoid escape. The jars were arranged in completely randomized design (CRD) in the laboratory.

Data Collection

Data were collected on insect mortality daily. Insects were confirmed dead after probing with a pin, and no response was seen. The total number of dead insects was counted on the next day after the onset of the experiment i.e. after 24 hours. On that day, all the dead insects were removed from the plastic jar in order to distinguish them from those that were alive, and this was continued after every 24 hours for 10 days. The mean mortality and percent mortality was recorded. Percent mortality was calculated by the formula (Niber, 1994):

$$\text{Percent mortality (\%)} = \frac{Number\ of\ dead\ insects}{Total\ number\ of\ insects} \times \frac{100}{1}$$

Data Analysis

The data on mortality, weight loss and viability were subjected to analysis of variance (ANOVA) using SAS. Means found to be significantly different were compared using Duncan Multiple Range Test (DMRT) at P<0.05 significance.

RESULTS

Toxicity of neem, moringa and lemon grass leaf powders on *C. maculatus* were evaluated after 1 and 2 days. Results indicate that all the three plant leaf powders were toxic to the insect, though the effect differ with the test material. Table 1 shows that after 1 day, neem and moringa leaf powders were statistically similar at all levels but more effective at 1.0 and 2.0g. The only treatments found to be significantly different are the highest doses of neem and lemon grass leaf powders (2.67 and 1.33). All the treatments are different from the control. After two days, all treatment were statistically the same, except 1.5g of neem leaf powder and 2.0g of lemon grass leaf powder. There is significant difference between second highest dose of moringa and neem leaf powder. The highest mortality after second day was in moringa leaf at 1.0 and 1.5 g, the least was in the control.

Table 1**:** Toxicity of neem leaf powder, moringa leaf powder and lemon grass leaf powder against *Callosobruchus maculatus* after day one and two

Treatments	(g/50g cowpea)	Mean mortality (day1)	Mean mortality (day 2)	Cumulative mortality
Neem leaf powder	1.0	2.67a	1.00ab	3.67
	1.5	1.67ab	0.67b	2.33
	2.0	2.67a	1.00ab	3.67
Moringa leaf powder	1.0	2.67a	2.00ab	4.67
	1.5	1.67ab	2.33a	3.99
	2.0	2.67a	1.33ab	4.00
Lemon grass leaf powder	1.0	2.33ab	1.33ab	3.66
	1.5	2.33ab	1.00ab	3.33
	2.0	1.33b	0.67b	2.00
Check (perm. 0.06%)	1.5	1.33b	1.00ab	2.33
Control	0.0	0.00c	1.33ab	1.33
CV		28.38%	59.44%	
SE		±0.162	±0.138	
S		*	*	

Means followed by the same letter(s) in column are not significantly different using Duncan's Multiple Range Test (DMRT) at 5% level of significance.

After three days (Table 2) the result shows that neem leaf powder at 1.5 g dose was more effective and statistically similar with 2.0 g of moringa and lemon grass leaf powder, also, significantly (p<0.05) higher than neem leaf powder at 1.0g. Check, control and all other treatments show no significant (p>0.05) difference between them. On day four check was more effective and statistically similar to 1.5 and 2.0 g of lemon grass and neem leaf powder. Control, 1.0 and 1.5 of moringa leaf powder, 1.5 and 2.0 of neem leaf powder, lemon grass leaf powder at 2.0 g were statistically similar. There was significant difference (p<0.05) between check and 1.0 g of neem and lemon grass leaf powder. Also, at the end of the fourth day, moringa leaf maintained the lead by having more than six dead insects, out of 8 (75%), similar to the two doses of neem and highest dose of lemon grass.

Table 2: Toxicity of neem leaf powder, moringa leaf powder and lemon grass leaf powder against *Callosobruchus maculatus* at day three and four

Treatments	(g/50g cowpea)	Mean mortality (day3)	Mean mortality (day4)	Cumulative mortality
Neem leaf powder	1.0	1.67abc	0.33b	5.67
	1.5	2.67a	1.00ab	6.00
	2.0	1.33bcd	1.00ab	6.00
Moringa leaf powder	1.0	0.67cd	1.33ab	6.67
	1.5	0.67cd	1.67ab	6.33
	2.0	2.00ab	0.67b	6.67
Lemon grass leaf powder	1.0	1.00bcd	0.33b	4.99
	1.5	1.33bcd	1.00ab	5.66
	2.0	2.00ab	2.00ab	6.00
Check (perm. 0.06%)	1.5	0.67cd	2.33a	5.33
Control	0.0	0.33d	1.00ab	2.66
CV		49.99%	74.06%	
SE		±0.154	±0.164	
S		*	*	

Means followed by the same letter(s) in column are not significantly different using Duncan's Multiple Range Test (DMRT) at 5% level of significance.

Table 3 reveals that on the fifth day, the highest mortality was in 1.0 and 2.0g of neem leaf powder and 2.0g of moringa leaf powder. All the treatments including check and control were statistically same, with no significant difference (p >0.05) between them. By the sixth day, check and control were statistically similar and only different from highest dose of moringa.

Table 3: Toxicity of neem leaf powder, moringa leaf powder and lemon grass leaf powder against *Callosobruchus maculatus* at day five and six.

Treatments	(g/50g cowpea)	Mean mortality (day5)	Mean mortality (day 6)	Cumulative mortality
Neem leaf powder	1.0	1.33a	1.00ab	8.00
	1.5	1.00a	0.67ab	7.67
	2.0	1.33a	0.67ab	8.00
Moringa leaf powder	1.0	1.00a	0.33ab	8.00
	1.5	0.67a	1.00ab	8.00
	2.0	1.33a	0.00b	8.00
Lemon grass leaf powder	1.0	0.67a	1.00ab	6.67
	1.5	0.33a	1.00ab	6.99
	2.0	0.67a	0.33ab	7.00
Check (perm. 0.06%)	1.5	1.00a	1.33a	7.66
Control	0.0	1.00a	1.33a	4.99
CV		80.88%	76.54%	
SE		±0.127	±0.113	
S		*	*	

Means followed by the same letter(s) in column are not significantly different using Duncan's Multiple Range Test (DMRT) at 5% level of significance.

All other treatments showed no significant (p>0.05) difference. By the seventh day (Table 4), all insect treated with permethrin (check), neem and moringa leaf powder were dead, while those in lemon grass leaf powder survived up to the eighth day and those in control up to the tenth day. It can be observed that on the sixth day all moringa treated insects and two levels of neem did not survive, while on the seventh day all neem and moringa leaf treated seeds had no survivors. On the 8th day, all the treatments were significantly similar, and all the insects were dead, except those in control, where few survived.

Table 4: Toxicity of neem leaf powder, moringa leaf powder and lemon grass leaf powder against *Callosobruchus maculatus* at day seven and eight.

Treatments	(g/50g cowpea)	Mean mortality (day 7)	Mean mortality (day 8)	Cumulative mortality
Neem leaf powder	1.0	0.00a	0.00c	8.00
	1.5	0.33a	0.00c	8.00
	2.0	0.00a	0.00c	8.00
Moringa leaf powder	1.0	0.00a	0.00c	8.00
	1.5	0.00a	0.00c	8.00
	2.0	0.00a	0.00c	8.00
Lemon grass leaf powder	1.0	0.33a	1.00a	8.00
	1.5	0.33a	0.67ab	8.00
	2.0	0.67a	0.33bc	8.00
Check (perm. 0.06%)	1.5	0.33	0.00c	8.00
Control	0.0	0.33a	1.00a	6.32
CV		201.01%	90.27%	
SE		±0.072	±0.079	
S		*	*	

Means followed by the same letter(s) are not significantly different using Duncan Multiple Range Test (DMRT) at 5% level of significance.

Table 5: Toxicity of neem leaf powder, moringa leaf powder and lemon grass leaf powder against *Callosobruchus maculatus* at day nine and ten

Treatments	(g/50g cowpea)	Mean mortality (day9)	Mean mortality (day10)	Cumulative mortality
Neem leaf powder	1.0	0.00b	0.00b	8.00
	1.5	0.00b	0.00b	8.00
	2.0	0.00b	0.00b	8.00
Moringa leaf powder	1.0	0.00b	0.00b	8.00
	1.5	0.00b	0.00b	8.00
	2.0	0.00b	0.00b	8.00
Lemon grass leaf powder	1.0	0.00b	0.00b	8.00
	1.5	0.00b	0.00b	8.00
	2.0	0.00b	0.00b	8.00
Check (perm. 0.06%)	1.5	0.00b	0.00b	8.00
Control	0.0	1.00a	1.00a	8.00
CV		287.23%	0.0%	
SE		±0.042	±0.050	
S		*	*	

Means followed by the same letter(s) are not significantly different using Duncan Multiple Range Test (DMRT) at 5% level of significance.

On the ninth day, Table 5 there was one insect that survived up to the tenth day, implying that in the absence of chemicals, *C. maculatus* could survive at 31.9 ^{0}C and relative humidity of 15.5 %. Summary of mortality from first to the tenth day (Table 5) indicated all insects treated with moringa leaf died after six days, those in neem after seven days and lemon grass after eight days, leaving those in the control to survive up to the tenth day. This implies that moringa and neem leaf powders were comparable to the check. It shows that the highest weight loss was in control, followed by lemon grass and least was in check, which was significantly different from neem and moringa. The weight loss was low, the highest being in neem at lower dose (0.81g or 1.62 %) as indicated in Table 6.

Table 6: Mean weight loss of the cowpea seeds after exposure to different treatments.

Treatment	(g/50g cowpea)	weight loss(g)	weight loss (%)
Neem leaf powder	1.0	0.81b	1.62
	1.5	0.70bc	1.4
	2.0	0.48de	0.95
Moringa leaf powder	1.0	0.47de	0.95
	1.5	0.45de	0.89
	2.0	0.37e	0.75
Lemon grass leaf powder	1.0	0.77b	1.53
	1.5	0.57cd	1.14
	2.0	0.69bc	1.38
Check (permethrin	1.5	0.2f	0.39
0.06%)	0.0	1.18a	2.37
Control		17.02%	
CV		±0.047	
SE		*	
S			

Means followed by the same letter(s) are not significantly different using Duncan Multiple Range Test (DMRT) at 5% level of significance.

DISCUSSION

The insect mortality increased with increasing application rate or dosage. The percentage mortality obtained at 2.0/50g was high, in agreement with Anita *et al.* (2012) who reported that there was about 100% mortality at application rate of 2.0g/10g. The rates chosen followed the work of Anita *et al* (2012), who used 0.05–2.0 g and Kentenholz *et al.* 2007 in which they used 1-5% weight/weight of grains. Also, Ogunwolu and Odunlami (1996) applied plant materials in the range of 0.125 to 3g per 20g seeds. They observed that these rates were effective in reducing *C. maculatus* infestation and adult emergence and neem, pirimophos methyl and other plants had nearly 5 months residual effectiveness. Dike and Mbah (1992) recorded lower mortality of 20% at higher dose (5g) of lemongrass leaf power after 4 weeks of treatment. The findings indicated that even without any form of treatments adults do not live longer than 10 days (Salunkhe and Gaikwad, 2023). The deterrence of oviposition and the reduction of adult emergence of *C. maculatus* by the neem, moringa and lemon grass leaf powder were also concentration dependent. The powdered leaves of neem, moringa and lemon grass plant caused significant reduction in the emergence of *C.*

maculatus. All of the extracts tested resulted in a significant reduction in oviposition, percentage egg hatch and percentage adult emergence in *C. maculatus* (Makanjola, 1989).

This reduction in emergence could either be due to egg, or larval mortality or even reduction in the hatching of the eggs. It has been reported that the larvae which hatch from the eggs of *C.* spp. must penetrate the seeds to survive (FAO, 1999). The larvae would be unable to do so unless the eggs are firmly attached to the seed surface. It could also be as a result of feeding deterrence, resulting in the death of the insects or ovicidal action leading to reduced progeny production as has been the case with other plant materials (Tapondjou *et al*., 2002; Abdelgaleil and Nakatani, 2003) and as found in this study. As the progenies emerged, more dead adult insects were observed than live ones which could be due to the bitter taste of neem, moringa and lemon grass and the biochemical constituents present which invariably deterred feeding. This shows that the leaves of neem, moringa and lemon grass are effective to protect cowpea seeds and other grains in the store, and the farmers can easily prepare and apply them to protect their grains in the store.

Moringa leaves resulted in total mortality after 6 days, which disagrees with Booker (1967) which stated that the mean length of life of females was 6.8 days. Caswell (1956) observed that a female will lay eggs and die after about six days. Tun (1979) reported that the mean length of life of mated females was only 4.7 days with a range of two to ten days. The mean length of life of males was 6.9 days (Caswell, 1956; Booker, 1967). Salunkhe and Gaikwad (2023) reported that the duration of the adult male and female were 10-12 and 10-14 days, respectively, with the total developmental period being 38 to 40 days. Males may live a day longer than the female. Like the females, mean length of life of females was 5.8 days, with a range of four to ten days. Similarly, Beck and Blumer, 2007 observed that the generation time was 3-4 weeks. Using moringa leaf powder 50% mortality was recorded after two days, similar to Anita *et al.* (2012) which observed 50% mortality of larvae within first two days.

It is clear from the result that neem, moringa and lemon grass leaf powder have insecticidal and feeding deterrent effects on *C. maculatus* on stored cowpea. With regards to seed quality, little damage from weevils was recorded in the seeds treated with the applied treatments compared to the control. This could be attributed to the fact that both organic and inorganic insecticides containing active constituents have the potential to protect stored seeds of cowpea by either repelling or disrupting the feeding activities of these weevils, either in the field or in storage (David, 2019; Ukoroije and Otayor, 2020; Ileke *et al*., 2020). The findings agree with Paul *et al.* (2009) and Fotso *et al*. (2018), which reported that powdered plant parts could adequately protect stored grains against storage insects and pests. The presence of the active ingredient azadirachtin in the leaves of neem may explain the reduction in weevil activity in seeds treated with neem leaf powder. Azadirachtin could be used as an insect repellent, a feeding inhibitor, a growth retardant, and a sterilant. Azadirachtin has both direct and systemic action on the eggs and on insects, thereby reducing their survival (Isman, 2006; Castilhos *et al.*, 2018). Azadirachtin has an antifeedant, sterilizing, and morphogenic effect on target pest species when elaborating on the pesticide properties of neem (Katamssadan *et al.*, 2016). It is structurally similar to the insect hormone ecdysone, which controls the moulting process. Neem, moringa and lemon grass leaf powders, therefore confirmed the properties required in chemicals for controlling insect feeding on plants which include toxicity to adults, reduction of oviposition, ovicidal activity and toxicity to immature stages prior to or immediately following penetration of plant tissues (Ogunwolu and Odunlami, 1996). This study has shown that the leaves of neem, moringa and lemon grass powder are effective as oviposition deterrence. Oviposition deterrence activity of neem suspension showed reduction in egg laying of gravid female by 89% (Kale *et al.*, 2019) and Anita *et al*. (2012) who confirmed that leaves of *Annona squamosa*, *Moringa oleifera* and *Eucalyptus globulus* were effective as oviposition deterrence. In all the treatments, the neem, moringa and lemon grass powders at 2.0g/50g weight/weight had the highest potency of insecticidal properties, its effect was clearly observed on the mortality rate of the insect.

The biologically active compounds present on the neem leaves are alkanoids, glycosides, tannis, flavinoids, reducing sugars, carbohydrates and steroids (Manikanden *et al*., 2008). Also, neem leaf powder at 10 g concentration was found to be effective on the stored rive weevil (Jahan *et al.*, 2019), while in moringa alkaloids, tannis and saponins were responsible for its toxicity and feeding deterrent effect. The toxicity of lemon grass leaf powder may be due to geraniol which is an insecticidal compound. Treatment effects on weevil populations at different levels were statistically similar, which is an indication that three botanicals have the potential to reduce seed damage and weevil populations when used as bio-pesticides and are similar to check. Consumers may prefer seeds treated with botanicals because they are easily degradable, affordable and safe.

CONCLUSION

The application of neem, moringa and lemon grass leaf powder on the Sampea 20-T or Bt cowpea significantly reduced seed damage and weevil populations over the untreated control. Moringa and neem leaf powder were more effective even at lowest doses (1.0g/50g) than lemon grass leaf powder. This indicated toxicity and feeding deterrent effect of the leaf powder. The toxicity of lemon grass leaf powder was significant, though not as effective as the others. Treatment effects on weevil populations at different levels is an indication that the three botanicals have the potency to reduce seed damage and weevil populations when used as bio-pesticides and are similar to check. Consumers may prefer seeds treated with botanicals because they are less toxic compared to synthetics.

In view of the above, it is recommended that neem and moringa leaf powder be used in storage of cowpea seeds to reduce infestation by *C. maculatus* at 1.0g/50g of cowpea seeds at this rate 2kg of the test material is needed for 100kg bag, equivalent to 2%. The use of these botanicals reduces the harmful effects of synthetic insecticides to man and the environment. Therefore, it should be adopted by cowpea farmers in sub-Saharan Africa as an alternative, cheap, and available source of bio-pesticide. Farmers can use either neem or moringa leaf powder to store cowpea seeds because their leaves are always available all year and there is no significant difference between the neem and moringa leaf powder treatments. More so, if cowpea seeds are to be stored and used for food or consumption, then farmers can use moringa leaf powder, since it does not negatively affect the taste of the seeds after storage. This genetically modified cowpea bred for resistance to field pest, in particular maruca pod borer (*Maruca testulalis*) has the potential for resistance to storage pest, *Callosobruchus maculatus* as only 1.62% weight loss was observed, unlike 33 % weight loss in some varieties recorded by Tengey *et al*., 2023.

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