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Original Article

Toxicity of Selected Botanicals Leaf Powder Against Maize (Sitophilus Zeamais Motschulsky) and Cowpea Bruchid (Callosobruchus Maculatus Fabricius)

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Abstract *- This study evaluated the insecticidal efficacy of Moringa oleifera, Blighia sapida leaf powder, and Parkia biglobosa husk powder against cowpea bruchid (Callosobruchus maculatus Fabricius) and maize weevil (Sitophilus zeamais Motschulsky) in a completely randomized design. the leaf powder was separately applied at 0.5 and 1.0 g per 20 g of cowpea and maize seeds in triplicate. Untreated seeds served as the negative control. Twenty (2-day old) mixed-sex C. maculatus and S. zeamais adults were introduced into cowpea and maize, respectively. Mortality was assessed post-treatment by 1, 2, 3, 4, and 7 days. Percentage weight loss, seed damage, and first filial generation (F1) emergence were evaluated 28 and 40 days after treatment, while seed viability was assessed after 3 months of storage. Data obtained were subjected to analysis of variance, and treatment means were separated using the New Duncan's Multiple Range Test (NDMRT) at a 5% significance level.*

Results showed the potency of the botanicals against Sitophilus zeamais and Callosobruchus maculatus adults. Insect mortality increases with dosage increment and duration of exposure to the treated grains. At 4 and 7 D.A.T. Moringa oleifera leaf powder (1 g / 20 g) showed higher efficacy against cowpea bruchid and maize (70%, 100% and 93.33%, 93.33%) than B. sapida leaf powder (60%, 98.33%) and P. biglobosa leaf powder respectively (53.33% and 95%). the botanicals leaf powders significantly (p< 0.05) reduced adult emergence, seed damage, and seed weight loss caused by C. maculatus and S. zeamais with no adverse effect on seed viability after 3 months of storage.

Keywords *- Callosobruchus maculatus, Sitophilus zeamais, Botanical leaf powder, Insecticidal, Moringa oleifera, Blighia sapida, Parkia biglobosa.*

1. Introduction

Maize (Zea mays L.) is one of Nigeria's most important cereal crops, belonging to the Gramineae family. It is rich in nutrients with 70-72% digestible carbohydrates, 4-5% fats and oils, and 9.5-11% proteins (LargerandHills,2001).Today, maize is one of the world's most important staple foods; maize, rice, and wheat combineto produce more than 50 % of the world's caloric intake (World Atlas, 2017). It is ranked below sorghum, millet, and rice as the fourth most consumed cereal (FAOSTAT, 2012).

Approximately 50 percent of all maize is eaten by humans as food in the developing world, while 43 percent is fed to livestock and the rest for industrial purposes (IITA, 2003). Cowpea (Vigna unguiculata L.) is one of the most leguminous grains in Nigeria and West Africa's farming system (Singh et al., 2002). Approximately 4.5 million metric tons of cowpea are produced annually worldwide, providing food primarily in developing countries for millions of people (Animasaun et al., 2015).

As the largest cowpea producer and buyer, Nigeria accounts for 61% of production in Africa and 58% worldwide (F.A.O., 2012; IITA, 2013).Several insect pests, including weevils, beetles,and moths, are a probem facing grain storage in Nigeriaand other African counties, leading to weight andseed quality loss(Akinkurolere et al.,2009; Adedire et al., 2011).

Cowpea bruchid (*Callosobruchus maculatus* Fabricius) and maize weevil (*Sitophilus zeamais* Motschulsky) are the major pests of pulses and cereals, respectively Ileleji *et al.* (2004) concluded that in a stored grain mass, the development of this pest might result in total damage to the grain kernels. However, most farmers depend on synthetic insecticides to manage insect pests in stored products to avoid such losses; these chemicals have been identified as the most common and efficient means of controlling stored pests (Carvalho *et al*., 2016).

However, in addition to immediate toxicity to users, several drawbacks such as high persistence, the reduced skill of application, high purchasing price, increasing pest resurgence, environmental contamination, food residues, genetic resistance by the insect, and lethal effects on beneficial organisms (Babarinde *et al*., 2016) necessitated a quest for readily accessible, inexpensive and eco-friendly alternatives of controlling insect pests of storage such as the use of botanicals (Kedia *et al*., 2015; Midega *et al*., 2016). Botanical insecticides could be considered suitable alternatives since they are price effective, eco-friendly, and easy to acquire and process (Habib *et al*., 2011; Babarinde *et al*., 2015). Several studies have shown the efficacy of botanical insecticides (Babarinde *et al*., 2011; War *et al*., 2014). *Azadirachta indica*, *Piper guineense, Allium cepa, Anethum graveolens, Senna species, and Annona senegalensis* (Ewete *et al*., 1996, Ofuya, 2001), among others, are plants whose parts like leaves, stems, roots have been used. *Moringa oleifera* powdered leaves have been established to be efficient against storage pests like *Tribolium castaneum* (Herbst.) (Anita *et al.*,2012) and *Trogoderma granarium Evert (* Babarinde *et al*., 2011). This study evaluates the efficacy of *Blighia sapida*, *Parkia biglobosa,* and *Moringa oleifera* leaf powder in mitigating *C. maculatus* and *S. zeamais* damage and loss to cowpea grains in storage.

2. Methodology

2.1. Experiment location

The experiment was conducted at the Entomology Laboratory of Nigerian Stored Products Research Institutes (NSPRI), Ilorin, Kwara State, Nigeria.

2.2. Purchase and handling of seeds

Un-infested white maize (IWDC2SXNF2) and Black-eyed cowpea (IT81D-994) obtained from the International Institute of Tropical Agriculture, Ibadan, Nigeria, were used for the experiment. the seeds were cold-shocked for 7 days to ensure infestation-free lots and later conditioned on the laboratory table before use.

2.3. Insect culture

Insect rearing followed Odeyemi *et al.* (2008). *Sitophilus zeamais* and *C. maculatus* adults were obtained from existing cultures in the Entomology Laboratory of NSRPI, Ilorin, Kwara State, Nigeria, and were separately mass-reared on IWDC2SXNF2 maize variety and IT81D-994 cowpea variety, respectively in 1-liter capacity Kilner jars covered with a muslin cloth to allow aeration and prevent insect escape at 26 ± 3^oC temperature and $65 \pm 5\%$ relative humidity. the parental generation of *Sitophilus zeamais* and *C. maculatus* adults were sieved out of the culturing jars after 14 days. the Kilner jars were undisturbed in the insectary until new progenies used for the bioassays emerged.

2.4. Collection and preparation of plant materials

All botanicals were obtained within Ilorin Metropolis, Kwara State, Nigeria; *Moringa oleifera* leaf, *Blighia sapida* leaf (Asa Dam area), and *P. biglobosa* husk was obtained from its tree along with Ogbondoroko village. the botanicals leaves were air-dried on the laboratory bench for 21 days until crisps dried, and *P. biglobosa* husks were oven-dried at 42^oC until crisps dried the dried, and leaves and husks were ground to powder with an electric blender (Lapriva model no: La-t4pn) and sieved with 90-micron sieve to obtain a fine powder. Each powder was stored in an air-tight container before use.

2.5. Toxicity of the plant powders

Different dosages (0.5 and 1.0 g) of each plant powder were weighed in triplicate using an analytical weighing balance. Each was added separately to 20 g of clean, undamaged, and un-infested cowpea and maize seeds in a 150 ml bottle container. the grains in control had no treatment. the containers with their contents (grains and treatment) were gently shaken for 5 minutes to ensure a thorough mixture of cowpea, maize seeds, and treatment powders.

Twenty (2-day-old) mixed-sex *C. maculatus and S. zeamais* were separately introduced into the containers containing treated grains and control. Three replicates of each treatment and untreated controls were laid out in a completely randomized design (C.R.D.).   Adult mortality was assessed after 1, 2, 3, 4, and 7. the insects were confirmed dead when there was no response to probing with the sharp pin on the abdomen (Adedire *et al*., 2011). Dead insects were removed and live ones retained.

2.5.1. Seed damage parameters

At the 14 D.A.T., dead and live insects were removed from each experimental unit. At 40 D.A.T., F1 progeny emergence of S. *zeamais* from each replicate was determined by counting the emerged insect in each container, and the maize seeds were re-weighed; the percentage loss in weight was determined and recorded according to Odeyemi and Daramola (2000).

$$\% \text{ Weight loss} = \frac{\text{Initial weight} - \text{final weight}}{\text{Initial weight}} \times 100$$

After re-weighing, the number of damaged grains was evaluated by counting wholesome and boring seeds with weevil emergent holes. Percentage seed damage was also calculated.

The percentage of seed damaged was also calculated as follows:

$$\% \text{ seed damage} = \frac{\text{Number of seeds damaged}}{\text{Total no of seeds}} \times 100$$

for *C. maculatus,* data on F1 progeny emergence were collected at 28 D.A.T. Percentage weight loss and seed damage was evaluated for cowpea seeds, following the same methodology used for maize seed.

2.6. Viability assessment

A seed viability test was conducted on 20 g of cowpea grains treated with 0.5 g and 1.0 g concentration of plant powder kept at ambient conditions for 3 months to assess the effect of the plant powder and seed extract on the viability of cowpea and maize grains. Twenty grains were randomly picked from the stored cowpea grain, planted in moist sand loamy soil in plastic, and the Germination count was taken on the 7th day Percentage germination was calculated thus:

$$\% \text{ Germination} = \frac{\text{Number of grains that germinated}}{\text{Total number of grains planted}} \times 100$$

2.7. Statistical analysis

Data obtained were subjected to analysis of variance, and significant treatment means were separated using the Duncan's New Multiple Range Test at a 5% significance level.

3. Results

3.1. Toxicity of botanicals leaf powders against Callosobruchus maculatus

As presented in Table 1, at 0.5 g / 20 g, there was no significant difference in bruchid mortality among all treatments 1 day after treatment (D.A.T.). At 1.0 g /20 g seed, there was no significant difference between cowpea treated with P. biglobosa (10.00%) and B sapida (6.67%) but significantly different from cowpea treated with M. oleifera (0.00%) and the untreated control (0.00%). At 2 D.A.T., M. oleifera caused significantly higher mortality (23.33%) when applied at 0.5 g/20 g seed and 1.0 g /20 g seed (26.67%) than mortality (10.00%) observed when 0.5 g /20 g seed P. biglobosa and B. sapida (6.67%) were applied. There was no mortality in control. At 3 D.A.T., M. oleifera significantly induced higher mortality when applied at 0.5 g /20 g seed (33.33%) and 1.0 g /20 g seed (40.00%) than mortality observed when 0.5 g /20 g seed P. biglobosa (13.33%) and B. sapida (20.00). There was no mortality in control.

At 4 D.A.T., M. oleifera caused significantly higher mortality when applied 0.5 g /20 g seed (66.67%) and 1.0 g /20 g seed (70.00%) than mortality observed for 0.5 g /20 g seed P biglobosa (30.00%) and B. sapida (60.00). Control had no mortality. At 7, D.A.T.s caused significantly higher percentage mortality (91.67-100%) than what was observed in the untreated control (23.33-60%)

Table 1. Effect of the botanical leaf powder on mortality (%) of *Callosobruchus maculatus*

Treatment	Dosage g/ 20 g	Days After Treatment 1	2	3	4	7
Mo	0.5	0.00 ± 0.00^{a}	23.33±3.33^{b}	33.33±3.33^{b}	66.67±3.33^{c}	96.67±3.33^{b}
Pb	0.5	0.00 ± 0.00^{a}	10.00±5.77^{a}	13.33±3.33^{b}	30.00±5.77^{b}	91.67±4.41^{b}
Bs	0.5	6.67 ± 3.33^{a}	6.67±3.33^{a}	20.00±10.00^{b}	60.00±5.77^{c}	93.33±6.67^{b}
Mo	1.0	0.00±0.00^{a}	26.67±6.67^{b}	40.00±5.77^{b}	70.00±5.77^{b}	100.00±.0.00^{b}
Pb	1.0	10.00±0.00^{b}	16.67±6.67^{ab}	23.33±8.82^{b}	53.33±6.67^{b}	95.00±2.89^{b}
Bs	1.0	6.67±3.33^{b}	13.33±3.33^{ab}	36.67±8.82^{b}	60.00±10.00^{b}	98.33±1.67^{b}
Co		0.00±0.00^{a}	0.00±0.00^{a}	0.00±0.00^{a}	0.00±0.00^{a}	23.33±3.33^{a}

Each value is a mean ± standard error of three replicates. Mean followed by a similar letter in a column are not significantly different (P<0.05) from each other using the new Duncan multiple range test.

Co- Control, Mo- Moringa oleifera, Pb- Parkia biglobosa, Bs- Blighia sapida

3.2. Effect of the botanical leaf powder on the reproductive parameter of Callosobruchus maculatus, protection of cowpea seed, and seed germinability

In Table 2, all treatments had a significantly different effect on *C. maculatus* adult emergence from the control. All botanical treatments reduced the emergence of insects at all dosages, which was significantly different from the control. for percentage grain damage, *M. oleifera* (3.17%) applied at 0.5 g /20 g seeds, 1.0 g /20 seed (3.07%), and *P. biglobosa* (3.24%) applied at 1.0 g /20 g seeds evoked significant prevention of grain damage when compared with the level of damage observed in the unprotected control (6.05%). the treatments did not significantly affect percentage weight loss, and the values ranged from 0.83-2.83%. for Germination at 0.5 g and 1.0 g, there was no significant difference between the treatments and control, which showed that the treatment had no negative effect on the viability of the grain at both dosages.

Table 2. Effect of Botanical Leaf Powder on the Reproductive Parameters of *Callosobruchus maculatus*, Protection of Cowpea Seed, and Seed Germinability

Treatment	Dosage g/20g	(%) grain damage	(%) weight loss	F1 Emergence	(%) Germination
Mo	0.5	3.17±0.44[a]	1.33±0.17[a]	0.33 ± 0.33[a]	91.68 ±1.67[a]
Pb	0.5	4.64 ±0.42[ab]	2.50 ±1.00[a]	0.33 ± 0.33[a]	90.00 ±2.87[a]
Bs	0.5	4.84 ±0.56[ab]	2.67±0.67[a]	4.67 ± 3.71[a]	91.67 ±1.67[a]
Mo	1.0	3.07 ±0.42 [a]	0.83 ± 0.17[a]	1.33±0.88[a]	93.33±4.41[a]
Pb	1.0	3.24 ±0.41[a]	1.83 ± 1.60[a]	1.67±0.67[a]	88.33±4.41[a]
Bs	1.0	4.17 ±1.07[ab]	2.83 ± 2.73[a]	4.67±0.00[a]	86.67±1.67[a]
Co	0.5	6.05±1.00[b]	2.67±1.42[a]	28.00 ± 0.58[b]	93.33± 4.41[a]

Co - Control, Mo- Moringa oleifera, Pb- Parkia biglobosa, Bs- Blighia sapida
Each value is a mean of ± standard error of three replicates. Mean followed by the similar letter in a column are not significantly different (P<0.05) from each other using the new Duncan multiple range test. F1: First filial

3.3. Toxicity of botanical powder against Sitophilus zeamais

When the botanicals were applied at 0.5g /20 g seed, maize treated with *B. sapida* leaf had the highest mortality of (8.33%), which was significantly different from maize treated with *M. oleifera* (0.00%) and *P. biglobosa* (3.33%) at 1 D.A.T., when the powder was applied at 1.0 g/ 20 g seed there was no significant difference in *S. zeamais* mortality among all treatments. At 2 D.A.T., there was no significant difference in *S. zeamais* mortality among all treatments when 0.5 g and 1.0 g /20 g of maize was applied (Table 4).

At 3 D.A.T., maize treated with *P. biglobosa* leaf powder had higher mortality when applied at 0.5 g /20 g of seed (56.67%) than mortality observed when *M. oleifera* was applied to a 0.5 g /20 g seed (46.67%), and *B. sapida* (25.00%) was applied. At 1.0 g /20 g, maize treated with *M. oleifera* and *P. biglobos*a had the highest mortality (73.33% and 66.67%, respectively) than maize treated with *B. sapida* (41.67%). At 4 D.A.T., maize treated with *P. biglobosa* and *B. sapida* had higher mortality of 66.67% and 58.33%, respectively, when applied at 0.5 g /20 g of seed. At 1.0 g /20 g seed, *M. oleifera* leaf powder had higher mortality of 73.33% than mortality observed when 1.0 g /20 g of P. *biglobosa* (66.67%) and *B sapida* (41.67%) was applied. At 7 D.A.T., there was no significant difference in *S. zeamais* mortality among all treatments when 0.5 g /20 g seed, *B. sapida* had the highest mortality of 90%, *M. oleifera* had a mortality of 83.33%, and *P. biglobosa* had a mortality of 73.33%. At 1.0 g /20 g seed, there was no significant difference in weevil mortality among all treatments. Maize treated with 1.0 g /20 g seed had higher weevil mortality of 93.33%. At 14 D.A.T., all treatments had no significant difference when 0.5g /20 g and 1.0 g /20 g of seed was applied. More than 80% mortality was observed in all treatments when 0.5 g /20 g of seed was applied. At 1.0 g /20 g, 100% mortality was observed in all treatments (Table 3).

Table 3. Effect of Botanical Powder on Mortality (%) of *S. zeamais*

Treatment	Dosage g/20g			Days After Treatment		
		1	2	3	4	7
Mo	0.5	0.00±0.00[a]	20.00±5.77[a]	46.67±13.33[ab]	53.33±12.02[a]	83.33±3.33[b]
Pb	0.5	3.33±3.33[ab]	20.00±5.77[a]	56.67±12.02[b]	66.67±12.02[b]	73.33±12.02[b]
Bs	0.5	8.33±1.67[b]	11.67±4.41[a]	25.00±2.89[a]	58.33±4.41[b]	90.00±7.64[b]
Mo	1.0	10.00±5.77[a]	23.33±3.33[a]	73.33±8.82[b]	93.33±3.33[c]	93.33±3.33[b]
Pb	1.0	6.667±3.33[a]	26.67±3.33[a]	66.67±8.82[b]	76.67±8.82[bc]	90.00±5.77[b]
Bs	1.0	11.67±1.67[a]	11.67±1.67[a]	41.67±14.24[a]	61.67±13.02[b]	90.00±5.77[b]
Co		0.00±0.00[a]	10.00±5.77[a]	20.00±7.64[a]	21.67±1.67[a]	26.67±3.33[a]

Each value is a mean of ± standard error of three replicates. Mean followed by the similar letter in a column are not significantly different (P<0.05) from each other using the new Duncan multiple range test
Co- Control, Mo- Moringa oleifera, Pb- Parkia biglobosa, Bs- Blighia sapida

3.4. Effect of botanical leaf powder on the reproductive parameters of S.zeamais, protection of maize seed, and seed germinability

As presented in Table 2, all treatments differed significantly from the control. the emergence of maize weevil at 0.5 g *P. biglobosa*, *M. oleifera*, and *B. sapida* (0.33, 0.33, 0.00) and 1.0 g (1.67, 1.33, 0.00) were significantly lower than the untreated control (28.00). for percentage grain damage, *M. oleifera* (3.17%) applied at 0.5 g /20 g seeds, 1.0 g /20 g seed (3.07%), and *P. biglobosa* (3.24%) applied at 1.0 g /20 g seeds evoked significant prevention of grain damage when compared with the level of damage observed in the unprotected control (6.05%). the treatments did not significantly affect percentage weight loss, and the values ranged from 0.83 to 2.83%. At both dosages, Germination was not significantly affected by the treatments, and the value ranged from 86.67% to 96.67 % at 0.5 g /20 g of grain and 86.67% to 91.67 % at 1.0 g /20g of grain. At 0.5 g /20 g, maize treated with *P. biglobosa* had the highest viability of 96.67%, and maize treated with *M. oleifera* had the lowest viability of 86.67%.

Table 4. Effect of Botanical Leaf Powder on the Reproductive Parameters of *S. zeamais* and Protection of Maize Seed

Treatment	Dosage g /20g	(%) grain damage	(%)weight loss	F1 Emergence
Mo	0.5	3.17± 0.44[a]	1.33±1.67[a]	0.33±0.33[a]
Pb	0.5	4.64± 0.42[a]	1.33±1.67[a]	0.33± 0.33[a]
Bs	0.5	4.84±0.56[ab]	2.67±0.67[ab]	0.00± 0.00[a]
Mo	1.0	3.07± 0.42[a]	0.83±0.17[a]	1.33± 0.88[a]
Pb	1.0	3.24 ±0.41[a]	1.83±0.61[a]	1.67± 0.67[a]
Bs	1.0	4.17±1.07[ab]	2.83±1.45[a]	0..00±0.00[a]
Co		6.05 ±1.00[b]	3.83±1.20[b]	28.00±0.58[b]

Each value is a mean of ± standard error of three replicates. Mean followed by the similar letter in a column are not significantly different (P<0.05) from each other using the new Duncan multiple range test.

Co- Control, Mo- Moringa oleifera, Pb- Parkia biglobosa, Bs- Blighia sapida F1: First filial

3.5. Phytochemical Analysis of the Studied Botanicals

The phytochemical screening of the studied botanicals showed that saponins, tannins, flavonoids, glycosides, and terpenoids alkaloids are present in the plant leaves and fruit husk of *Parkia biglobosa*. At the same time, phlobathanins were absent in the three botanicals that used steroids in *B. sapida* leaf but present in *P.biglobosa* husk and *M. oleifera* leaf; anthaquinones were present in only *M. oleifera* leaf as presented in Table 5.

Table 5. Phytochemical Analysis of the Studied Botanicals

Test / Samples	*M oleifera* leaf	*Parkia biglobosa* husk	*Blighia sapida* leaf
Saponins	+	+	+
Tannins	+	+	+
Flavonoids	+	+	+
Glycosides	+	+	+
Steroids	+	+	-
Phlobathannins	-	-	-
Terpenoids	+	+	+
Alkaloids	+	+	+
Anthraquinones	+	-	-

Key: + = Detected, - = Not detected

4. Discussion

This study showed that *M. oleifera*, *P. biglobosa*, and *B. sapida* leaf powder shows a significant insecticidal effect on *C. maculatus* and *S. zeamais*. the leaf powders were toxic to the weevils. the mortality of the insects was dosage-dependent, which implied that the higher the dosage of the treatments, the higher the mortality of the insects. Also, their mortality depended on the duration of exposure of the insects to treated maize and cowpea grains. the toxicity of Moringa powder and extract on survival and F_1 emergence have been reported by Mbailo *et al*. (2006). Ileke and Oni (2011) reported the toxicity of *M. oleifera* seed powder in reducing the longevity of *S. zeamais* on stored wheat grains. Therefore, the botanical leaf powder conformed to the properties needed in chemicals for controlling insect feeding on plants, including toxicity to adults, reduction of oviposition, ovicidal activity, and toxicity to immature stages before or immediately following penetration of plant tissues (Ogunwolu and Odunlami, 1996). the results of this study also agreed with the earlier reports (Paul *et al.*, 2009) that powdered plant parts could provide adequate protection for stored grains against storage insects. Deterrence of oviposition and the reduction of adult emergence of *C. maculatus* and *S. zeamais* may be attributed to either egg mortality, larval mortality, or even reduction in the hatching of the eggs. It has been stated that the larvae hatch from Callosobruchus sp. eggs must penetrate the seeds to survive (F.A.O., 1999*)*. A significantly lower number of emerged F_1 progeny relative to control suggested the presence of some active properties in the plants that had contact toxicity and fumigants action on the weevils (Adedire, 2003). the fact that the powders did not harm the viability of treated seeds is of great importance to the users who may wish to implement this technology to preserve cowpea and maize meant for planting.

Leaves of *M. oleifera*, *B. sapida,* and *P. biglobosa* were rich in alkaloids, saponins, tannins, flavonoids, and steroids. These compounds possessed insecticidal and larvacidal properties that caused mortality in insects and other pests (Nweze *et al*., 2004; Akinyemi *et al*., 2005; Gutierrez Jr. *et al*., 2014;). Alkaloids, saponins, and tannins possess medicinal and pesticide properties. Saponins are harmful to insects (Chaieb, 2010).

Saponins were detected in the leaves of the studied botanicals (*B. sapida*, *M. oleifera*, and *P. biglobosa*). Okwu. (2003) reported on the use of saponin in the manufacture of insecticides, drugs, and the synthesis of steroid hormones. Alkaloids detected in the studied samples' leaves are lethal to mosquito larvae (Wiesman and Chapagain, 2006; Ubulom *et al*., 2012). the leaves of the botanicals showed the presence of flavonoids. Joseph *et al*. (2004) reported on some flavonoids' larvicidal effects. the phytochemicals present in these plants could be responsible for the insect's residual toxic effects.

5. Conclusion

This study confirmed the presence of some phytochemical constituents in the botanicals, which enhanced insecticidal properties against Maize weevil and Cowpea bruchid. the study has shown that *M. oleifera*, *P. biglobosa,* and *B. sapida* leaf powder, when used to store cowpea and maize, offer good protection to the grain by maintaining grain quality and destroying various life stages of *C. maculatus* and *S. zeamais* through contact.

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