International Journal of Agricultural Research and Review
Abbreviated Key Title: Int. J. Agric. Res Rev.
ISSN: 2360-7971 Open Access: DOI Prefix: doi.org/10.54978
Vol. 14, Issue 8, Pp.: 136-145, September,, 2026.

Insecticidal Evaluation Of Some Botanical Seed Powders On Cowpea Beetle *Callosobruchus maculatus*(F.) On Stored Bambara Groundnut (*Vigna subterranea* (L.) Verdcourt

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Abstract

Two laboratory trials were conducted at the Department of Crop Protection, Faculty of Agriculture, Ahmadu Bello University, Samaru-Zaria, to evaluate the efficacy of five plant species. *Anogeissus leiocarpus* Guill. and Pel., Antidesma venosum Tull., Maranthes polyandra (Benth) Prance, Mitragyna inermis (Willd) Kuntze, and Vitex madiensis Olive were tested for their seed powders at two levels of concentrations (5.0 and 10.0 g/100 g seeds) as protectants against *Callosobruchus maculatus* F. infecting stored bambara groundnuts. Actellic dust 2.0% at 2.0 g/100 g seeds (treated check and untreated control) was placed alongside these plant seed powders to serve as checks. Treated and untreated experiments were infested with C. maculatus under prevailing storage. Antidesma venosum (AntSP) at 10g/100g seed recorded conditions. The two trials were consistent with each other. 45.9% mortality of C. maculatus in 24 hours post-treatment. Anogeissus leiocarpa (AnoSP) at a higher level had 61.7% mortality, and Maranthes polyandra (MarSP) had 43.5% mortality at 24 hours of treatment. At 48 hours post treatment, Vitex madiensis (VitSP) at both concentration levels recorded 56.3% and 57.9% mortality of C. maculatus. At 72 hours post treatment, AnoSP and VitSP, all at higher concentration levels, recorded 48.8% and 68.8% mortality of C. maculatus. The treatments VitSP, AnoSP, and MarSP resulted in low oviposition, with 5.64 and 6.76 eggs recorded, respectively. Treatments with MarSP, AntSP, MitSP, and AnoSP, all at 10 g/100 g seeds, recorded low F_1 progeny emergence of 1.73, 2.04, and 2.27, respectively. At 8 weeks, MarSP at both levels completely suppressed and inhibited F_3 filial progeny emergence, and on post-treatment, MarSP suppressed and inhibited the development of F_2 progeny emergence of C. maculatus. At 12 weeks, MarSP at both levels completely suppressed and inhibited F_3 filial progeny emergence and was on par with the Actellic 2.0 g/100 g seeds treatment, which recorded no F_3 filial progeny emergence. Seed damage and weight loss were relatively low in treatments using MarSP at 5.0 g and 10.0 g per 100 g of bambara groundnut seeds 12 weeks post-treatment. Moderate weight loss and seed damage were observed in all treatments using plant seed powder at 8 weeks post-treatment, particularly at higher concentration levels. *Maranthes polyandra* can be recommended to farmers for long-time storage of bambara groundnut, an alternative to synthetic chemicals like Actellic dust.

Keywords: Bioinsecticide, leguminous crops, stored products, insect antifeedant.

Accepted: 16-7-2026 Published 30-8-2026

NTRODUCTION:

Bambara groundnut, *Vigna subterranea* (L) Verdcourt, is a leguminous crop of the tribe Phaseolae, family Leguminosae, with creeping stems, branching just above ground level with a tap root system that is rounded or lobed with nodules. The leaves are alternate and trifoliate, glabrous; the flowers are bisexual, and the fruits are indehiscent pods of about 2.5 cm in diameter and usually one-seeded in nature. The seeds are in different colours ranging from white to cream, red, black or brown, sometimes mottled, blotched or striped (Linnman and Azam-Ali, 1993; PROTA, 2006; Sedhu et al., 2026).

Bambara groundnut is an indigenous African crop and is reported to have originated from north-eastern Nigeria and northern Cameroon, where the wild forms are still found (PROTA 2006).

The crop is grown primarily for its seeds, which are eaten fresh when semi-ripe and as a destabilisation of the ecosystem and pulse when dry and mature, or ground into flour (Killians 1993, Perzadar et al., 2025). Bambara groundnut is a major source of vegetable protein in sub-Saharan Africa, where it constitutes an important part of the local diet, culture and economy (Heller et al. 1997). The seed is regarded as a completely balanced food (Anchirina et al. 2001; Lacroix et al. 2003). Bambara groundnut seeds' hull and dry leaves are a source of livestock and poultry feed (Anchirina et al. 2001).

Callosobruchus maculates (F) and Callosobruchus subinotatus Pic. are the major storage insect pests of Bambara groundnut seeds in West Africa (Haines, 1991; Mbata, 1992; Bello et al., 2025). Of these bruchids, C. maculatus is the more destructive species due to its shorter life cycle, which can lead to destabilisation of the ecosystem (Lale and Vidal, 2001; Maling, 2004). These bruchids start infestations in the field and continue in storage when Bambara groundnut seeds are stored, thereby reducing the quality and quantity of the seeds (Dike, 1994).

In Nigeria, there are limited reports in the literature on effective methods for controlling *Callosobruchus maculatus* on Bambara groundnut in storage. Frequent use of synthetic insecticides may lead to a destabilisation of the ecosystem and to enhanced resistance to insecticides in pests. Botanicals have long been used as bioinsecticides and are safer than synthetic chemicals, being environmentally friendly and better for human health (Murray, 2005).

Several plant substances have been considered for use as insect antifeedants or repellents, but apart from some natural mosquito repellents, little commercial success has ensued for plant substances that modify arthropod behaviour (Murray, 2005; Parmar et al., 2025). The integration of insecticidal products from locally available plants for use in storage and the growing of various varieties of grain legumes with resistance to C. maculatus may lead to the sustainable management of the bruchid, especially in subsistence agriculture (Lale and Mustapha, 2001; Maina and Lale, 2004). Since there are increasing drawbacks of the continued use of today's conventional insecticides, efforts are needed in the development of new compounds to replace those currently being used (Bell and Killson, 1995; Bamayi et al., 2006).

In Nigeria, many botanicals are still unexploited, whose potentials appear to be quite high (Olaifa and Akingbohungbe, 1986). Therefore, the aims and objectives of this research were to investigate and evaluate the insecticidal efficacy of seed-powdered treatments of five plant species: *Anogeissus leiocarpus* (common name in African birch), *Antidesma venosum, Maranthes polyandra*, Metragyna inermis* (common name: false abura) and *Vitex madiensis* in the control of Bambara groundnut bruchid *Callosobruchus maculatus* in storage.

MATERIALS AND METHODS

Adult C. maculatus were obtained from already infected Bambara groundnut seeds from a warehouse at Samaru, Zaria, Nigeria. These were subsequently raised on pristine Bambara groundnut seeds [disinfected for two days with a phosphate tablet in an airtight Kilner jar] in the insect museum of the Institute for Agricultural Research (IAR), Ahmadu Bello University, Samaru, Zaria. The insects were sieved out from this initial infected batch of Bambara groundnut, and 100 pairs of gravid *C. maculatus* were re-infested on 2 kg of seeds of Bambara groundnut divided into four Kilner jars. This was done in order to maintain the stability and acclimatisation of *C. maculatus* in the laboratory.

Fresh Bambara groundnut seeds (25 kg) were obtained from Samaru market, Zaria, for the experiment. The seeds were treated with phostoxin tablets obtained from an agro-allied dealer for five days, and later the seeds were air-dried under a screen in the laboratory for 24 hr prior to the start of the experiment. Actellic dust 2% used in the experiment was also obtained from the same source. Five different plant species were collected from their natural habitat (bush) in Lafia and its environment in Nasarawa State. The plant samples were identified at the Herbarium of the Department of Biological Sciences, Ahmadu Bello University, Zaria, Nigeria. The plant samples identified were as shown in **Table 1**

Table 1. List of Plants Screened for the Efficacy of Their Stem Bark Powders

Plant Species	Family	Acronym Used
Anogeissus leiocarpus Guill. & Perr.	Combretaceae	Ano SP
Antidesma venosum Tul.	Euphorbiaceae	Ant SP
Maranthes polyandra (Benth.) Prance	Chrysobalanaceae	Mar SP
Mitragyna inermis (Willd.) Kuntze	Rubiaceae	Mit SP
Vitex madiensis Oliv.	Verbenaceae	Vit SP

Each seed sample of the five plant species was collected separately and air-dried under shade on the laboratory top bench in the open for three weeks. Thereafter, each plant part species was independently ground using a mortar and pestle and sieved with 0.1 mm wire mesh size. The pulverised contents obtained in each case were each kept in separate polyethylene bags and kept in the laboratory fridge until ready for use. 100 g of pristine Bambara groundnut seeds were placed in each 500 ml Kilner jar. Treatment consisted of two concentrations of the seed powders of the different plants applied at 5.0 and 10.0 g/100 g Bambara groundnut seeds, while Actellic dust 2.0% was applied at 2.0 g/100 g seeds to serve as treated checks. The control (untreated check) was also set up separately. All treatments were replicated three times.

All the jars, excluding the control, were vigorously shaken to ensure proper mixing of the plant products and Actellic dust with the Bambara groundnuts. The powdered treatments in each jar were allowed to settle for two hours. Thereafter, five pairs of freshly emerged *C. maculatus* adults were introduced into each jar, and the jars were properly covered with an aerated cap. The treatments were arranged in a completely randomised design (CRD) on the laboratory bench, and experiments were carried out under laboratory temperature and relative humidity.

DATA COLLECTION AND ANALYSIS

Determination of toxicity efficacy In each treatment, observations were made and recorded for toxicity effect on mortality rates in all the jars at 24, 48, 72 and 96 hours. Data collected were analysed as percentage rates of 51.9% and 50.3% for C. maculatus, which were significantly higher than the number of insects used for the experiments. After 14 days of infestation and of exposing the beetles to the treatments, 100 seeds of Bambara groundnut were randomly removed from each jar containing the treatments, and the number of eggs oviposited on them was counted. These were placed in another equal volume of Kilner jars separately until progeny emergence. Progeny emergence in each treatment and replicate was taken for F1, F2 and F3, respectively. At each time of observation the newly emerged progenies were sieved out, counted and recorded.

After 12 weeks of treatment, the percentage weight loss of the seeds was evaluated by weighing the entire Bambara groundnut seeds in each jar, and the difference from the initial weight of 100 g was transformed into percentage weight loss. The percentage seed damage was evaluated by randomly selecting 100 seeds from each jar and counting the number of holes on each seed of the treatments.

At the end of the 12-week trials, 10 seeds were randomly selected from each jar of all the treatments and placed on sterilised plastic petri dishes lined with moistened blotting paper and kept on the benches in the laboratory. Occasionally distilled water was added to the petri dishes to maintain a humid environment around the germinating seeds. The test was monitored for 9 days, after which the germination percentage counts were taken.

Organoleptic studies were conducted at the end of 12 weeks of treatment. A popular food, Okpa (a local delicacy made from ground and cooked Bambara groundnut), was made from each of the powdered treatments in their respective concentration levels. The food was separately tested for palatability and flavour retention of the powdered treatments. Visual observations were also made on the seed coat texture and colour changes in each of the treatments to ascertain the quality of the products that would appeal to market demand.

RESULTS

The seed powdered treatments of the five plant species at two levels (5.0 g and 10.0 g/100 g seeds of Bambara groundnut) at rates of 51.9% and 50.3% for C. maculatus, which were significantly higher than adult *Callosobruchus maculatus* at 24, 48, 72 and 96 hours post-treatments, were indicated in Table 2. At 24 hours post-treatment, *Antidesma venosum* (Antsp 45.4%) at a higher level recorded the highest rates of 51.9% and 50.3% for C. maculatus, which were significantly higher than *C*. maculatus, with the exception of the actellic dust treatment that recorded a 100% mortality rate of *C*. maculatus. This is followed by *Anogeissus leiocarpus* (AnoSP) and *Maranthes polyandra* (MarSP), all at both concentration levels, and AntSP at a lower level of treatment and *Vitex madiensis* (VitSP) at a higher level. The treatment is followed by *Mitragyna inermis* (MitSP) at a higher concentration level. The untreated control recorded the lowest mortality rate of *C*. *maculatus* at 24 hours post-treatment. At 48 hours post-treatment, *Vitex madiensis* (VitSP) (50.3%) at both levels of concentration recorded high rates of 51.9% and 50.3% for C. maculatus, which were significantly higher 51.9% and 50.3% of C. maculatus and a significantly higher rate than all other treatments at $P \geq 0.05$. This treatment is followed by AnoSP at a higher concentration level and MarSP at a lower concentration level, and they were at par with each other. Other remaining treatments using plant seed powder at both concentration levels recorded a moderate mortality rate of *C. maculatus.* Untreated control recorded low mortality at 48 hours post-treatment of *C*. maculatus. Observations at 72 hours post-treatment showed that *Anogeissus leiocarpus* (AnoSP) 48.8% and *Vitex madiensis* (VitSP) 48.8% at higher concentration levels were at par, and all are significantly better than all other treatments. At 96 hours post-treatment, *Maranthes polyandra* (MarSP) at both levels recorded a higher mortality rate of *C*. maculatus and was significantly higher than the remaining plant seed

Table 2: Effect of Five Bioinsecticide Seed Powders on the Mortality Rate (%) of *Callosobruchus maculatus* on Bambara Groundnut in Storage

Treatment	Conc. (g/100 g seed)	24 h Trials	48 h Trials	72 h Trials	96 h Trials
Anogeissus leiocarpus	5.0	1.08^{bc} (33.3)	1.29^{abc} (39.8)	1.22^{ab} (37.7)	1.36^{ab} (42.0)
	10.0	1.35^{bc} (41.7)	1.41^{ab} (43.5)	1.58^{a} (48.8)	1.16^{ab} (35.8)
Antidesma venosum	5.0	1.16^{bc} (35.8)	1.29^{abc} (39.8)	1.16^{ab} (35.8)	1.00^{bc} (30.9)
	10.0	1.47^{b} (45.4)	1.35^{abc} (41.7)	1.08^{ab} (33.3)	1.22^{ab} (37.7)
Maranthes polyandra	5.0	1.29^{bc} (39.8)	1.47^{ab} (45.4)	1.22^{ab} (37.7)	1.63^{a} (50.3)
	10.0	1.41^{bc} (43.5)	1.41^{abc} (43.5)	1.22^{ab} (37.7)	1.83^{a} (56.5)
Mitragyna inermis	5.0	0.92^{cd} (28.4)	1.15^{abc} (35.5)	1.36^{ab} (42.0)	1.47^{ab} (45.4)
	10.0	1.22^{c} (37.7)	1.29^{abc} (39.8)	1.36^{ab} (42.0)	1.41^{ab} (43.5)
Vitex madiensis	5.0	1.08^{bcd} (33.3)	1.68^{a} (51.9)	1.29^{ab} (39.8)	1.22^{ab} (37.7)
	10.0	1.41^{bc} (43.5)	1.63^{a} (50.3)	1.58^{a} (48.8)	1.16^{ab} (35.8)
Check (Actellic dust 2%)	2.0	3.24^{a} (100.0)	3.24^{a} (100.0)	3.24^{a} (100.0)	3.24^{a} (100.0)
Control (no treatment)	0.0	0.71^{d} (21.9)	0.17^{c} (21.9)	0.92^{b} (28.4)	0.82^{c} (25.3)
CV (%)		**29.08**	**65.08**	**68.70**	**62.51**
SE ±		**0.15**	**0.23**	**0.22**	**0.21**

Notes: 1. Means within the same column followed by the same letter(s) are not significantly different at $P \geq 0.05$ using Student–Newman–Keuls (SNK) grouping.
2. Means of the powders were compared among themselves within each column.
3. Figures in the table are transformed (square-root) values from the original data, while figures in parentheses are mortality percentages (%).
4. Initial number of insects used = 5 pairs.

powdered treatments, which all recorded a moderate mortality rate of C. maculatus. The untreated control recorded the least mortality rate of C. maculatus at 96 hours post-treatment. Effect of five biomaterials tide seed powders on oviposition and emergence After 8 weeks of exposure to treatments as shown in Table 3.

Table 3: Effect of Five Bioinsecticide Seed Powders on Oviposition (%) of *Callosobruchus maculatus* on Stored Bambara Groundnut after Two Weeks of Treatment

Treatment	Conc. (g/100 g seed)	Oviposition Trials
Anogeissus leiocarpus	5.0	6.88^{cd} (49.8)
	10.0	6.40^{cd} (46.3)
Antidesma venosum	5.0	7.79^{bc} (56.4)
	10.0	7.34^{bc} (53.1)
Maranthes polyandra	5.0	7.57^{bc} (54.3)
	10.0	6.76^{cd} (48.9)
Mitragyna inermis	5.0	8.29^{b} (60.0)
	10.0	7.90^{bc} (57.2)
Vitex madiensis	5.0	7.85^{bc} (56.8)
	10.0	6.65^{cd} (48.1)
Check (Actellic dust 2%)	2.0	2.89^{d} (20.9)
Control (no treatment)	0.0	13.82^{a} (100.0)
CV (%)		**12.8**
SE ±		**2.24**

Notes: 1. Means within the same column followed by the same letter(s) are not significantly different at $P \geq 0.05$ using Student–Newman–Keuls (SNK) grouping.
2. Means of the powders were compared among themselves within the column.
3. Figures in the table are transformed (square-root) values from the original data, while figures in parentheses are percentages (%).
4. Initial number of insects used = 5 pairs.

The data from the first and second trials followed a similar pattern. Treatments with VitSP, AnoSP and MarSP recorded moderate oviposition with 66.6, 69.4 and 67.6 eggs dropped/100 g seeds of bambara groundnut. Also, the concentration level of oviposition recorded low oviposition with 59/100 g seeds and 88/100 g seeds, respectively. Untreated control recorded the highest oviposition with 100%.

Table 4: Effect of Five Bioinsecticide Seed Powders on F_1, F_2 and F_3 Progeny Emergence (%) of *Callosobruchus maculatus* at 4, 8 and 12 Weeks of Treatment on Stored Bambara Groundnut

Treatment	Conc. (g/100 g seed)	F_1 (4 weeks) Trials	F_2 (8 weeks) Trials	F_3 (12 weeks) Trials
Anogeissus leiocarpus	5.0	2.58^{bc} (35.8)	4.42^{bc} (27.0)	12.77^{cd} (41.1)
	10.0	2.27^{bc} (31.5)	3.00^{bc} (18.3)	10.76^{cd} (34.6)
Antidesma venosum	5.0	2.77^{bc} (38.4)	3.85^{cd} (23.5)	14.94^{bc} (48.1)
	10.0	2.00^{bc} (7.7)	3.32^{bcd} (20.3)	12.49^{cd} (40.2)
Maranthes polyandra	5.0	2.45^{bc} (34.0)	0.71^{e} (4.3)	0.71^{d} (2.3)
	10.0	1.73^{bc} (24.0)	0.71^{e} (4.3)	0.71^{d} (2.3)
Mitragyna inermis	5.0	2.61^{bc} (36.2)	5.46^{b} (33.4)	19.17^{b} (61.7)
	10.0	2.04^{bc} (28.3)	4.04^{c} (24.7)	15.72^{bc} (50.6)
Vitex madiensis	5.0	2.92^{bc} (40.5)	5.18^{b} (31.6)	14.37^{bc} (46.2)
	10.0	2.65^{bc} (36.8)	4.36^{bc} (26.6)	11.83^{cd} (38.1)
Check (Actellic dust 2%)	2.0	0.71^{c} (9.8)	0.71^{e} (4.3)	0.71^{d} (2.3)
Control (no treatment)	0.0	7.21^{a} (100.0)	16.37^{a} (100.0)	31.09^{a} (100.0)
CV (%)		59.26	15.53	29.81
SE ±		1.39	1.86	18.61

Notes: 1. Means within the same column followed by the same letter(s) are not significantly different at $P \geq 0.05$ using Student–Newman–Keuls (SNK) grouping.
2. Means of the powders were compared among themselves within each column.
3. Figures in the table are transformed (square-root) values from the original data, while figures in parentheses are percentages (%).
4. Initial number of insects used = 5 pairs.

A progeny emergence – actellic dust treatment recorded a very low progeny emergence (table 4) at 0.71 f1 progeny emergency. Treatment with marsp, antsp, mitsp and anosp recorded low emergency OA of 1.73, 2.0, 2.04 and 2.27 f1progrny emergence when applied at 10 g by 100 g seed. Lower concentration levels of the plant treatment record high progeny emergence. At 8 weeks post-treatment, Marsp completely inhibited the development of f2 progeny emergence of C. marculatus, showing no significant difference compared to the inhibited development of f2 progeny emergence of C. marculatus and was not different from the atallic dust treatment (0.71). Treatment with anosp and antsp at 10 g/100 g seeds recorded low f2 progemy emergence. Higher progeny emergence of f_2 was observed at lower concentration levels of the treatment. The untreated control recorded the highest f_2 programme emergence. At 12 weeks post-treatment, marsp at both concentration levels completely inhibited the development of f_3 progeny. Anosp and Vitsp at a higher level recorded moderate F3 program emergence in C. maculatus. Mitsp at both concentration levels recorded high F3 progeny emergence, although this level of emergence was lower than that observed in the untreated control.

Weight loss – The percentage of weight loss in bambara groundnut due to C. maculatus at 12 weeks post-treatment, as shown in observation (Table 5), indicated that the actellic dust treatment resulted in a low weight loss of 12.8%, which was significantly different from all other treatments. The MarSP treatment follows at both levels, resulting in moderately low weight losses of 33.0% and 28.0%, which are comparable to each other. The treatment is followed by AnoSP and AntSP, with weight losses of 47.5% and 48.7% at 10 g/100 g seeds. VitSP at 5 g/100 g seeds recorded the highest weight loss of 97.1%, which is not significantly different from that of the untreated control.

Percentage seed damage. Observations made at 12 weeks post-treatment (Table 6) showed that the actellic dust treatment recorded the lowest seed damage, at 7.1%. The actellic dust treatment is followed by MarSP at both levels with 26.8% and 18.7% seed damage. The highest seed damages were observed in treatments with MitSP and VitSP, all at both concentration levels, recording 99.6%, 97.9%, 99.8% and 97.1%, and were not significantly different from the untreated control.

Percentage germination count of bambara groundnut seeds at 12 weeks post-treatments. At the end of 12

Table 5: Effect of Five Bioinsecticide Seed Powders on Percentage Weight Loss of Bambara Groundnut Due to *Callosobruchus maculatus* after 12 Weeks of Treatment

Treatment	**Conc. (g/100 g seed)**	**% Weight Loss (Trials)**
Anogeissus leiocarpus	5.0	2.77[c] (50.0)
	10.0	2.63[c] (47.5)
Antidesma venosum	5.0	3.02[c] (54.5)
	10.0	2.70[c] (48.7)
Maranthes polyandra	5.0	1.83[d] (33.0)
	10.0	1.55[d] (28.0)
Mitragyna inermis	5.0	4.97[b] (89.7)
	10.0	4.73[b] (85.4)
Vitex madiensis	5.0	5.38[a] (97.1)
	10.0	4.46[b] (80.5)
Check (Actellic dust 2%)	2.0	0.71[d] (12.8)
Control (no treatment)	0.0	5.54[a] (100.0)
CV (%)		**14.30**
SE ±		**0.55**

Notes: 1. Means within the same column followed by the same letter(s) are not significantly different at $P \geq 0.05$ using Student–Newman–Keuls (SNK) grouping.
2. Means of the powders were compared among themselves within the column.
3. Figures in the table are transformed (square-root) values from the original data, while figures in parentheses are percentages (%).
4. Initial number of insects used = 5 pairs.

Table 6: Effect of Five Bioinsecticide Seed Powders on Percentage Seed Damage of Bambara Groundnut Due to *Callosobruchus maculatus* after 12 Weeks of Treatment

Treatment	**Conc. (g/100 g seed)**	**% Seed Damage (Trials)**
Anogeissus leiocarpus	5.0	8.20[b] (81.8)
	10.0	6.53[c] (65.2)
Antidesma venosum	5.0	8.75[b] (87.3)
	10.0	7.67[b] (76.6)
Maranthes polyandra	5.0	2.61[d] (26.0)
	10.0	1.87[d] (18.7)
Mitragyna inermis	5.0	9.98[a] (99.6)
	10.0	9.81[a] (97.9)
Vitex madiensis	5.0	10.00[a] (99.8)
	10.0	9.73[a] (97.1)
Check (Actellic dust 2%)	2.0	0.71[d] (7.1)
Control (no treatment)	0.0	10.02[a] (100.0)
CV (%)		**14.11**
SE ±		**2.51**

Notes: 1. Means within the same column followed by the same letter(s) are not significantly different at $P \geq 0.05$ using Student–Newman–Keuls (SNK) grouping.
2. Means of the powders were compared among themselves within the column.
3. Figures in the table are transformed (square-root) values from the original data, while figures in parentheses are percentages (%).
4. Initial number of insects used = 5 pairs.

weeks post-treatment (Table 7), MarSP at both levels recorded the highest germination counts of 90.3% and 96.3%, and they were not significantly different from the actinic dust treatment, which recorded a 100% germination count. Treatments with MitSP at a lower level and VitSP recorded very low germination counts of 23.7% and 27.3%, respectively.

Table 7: Effect of Five Bioinsecticide Seed Powders on Percentage Germination Count of Bambara Groundnut at 12 Weeks Post-Treatment

Treatment	Conc. (g/100 g seed)	% Germination Count (Trials)
Anogeissus leiocarpus	5.0	1.69^{bc} (56.3)
	10.0	2.00^{b} (66.7)
Antidesma venosum	5.0	1.58^{bc} (52.7)
	10.0	2.00^{b} (66.7)
Maranthes polyandra	5.0	2.71^{a} (90.3)
	10.0	2.89^{a} (96.3)
Mitragyna inermis	5.0	0.71^{d} (23.7)
	10.0	1.15^{c} (38.3)
Vitex madiensis	5.0	0.82^{d} (27.3)
	10.0	1.29^{c} (43.0)
Check (Actellic dust 2%)	2.0	3.00^{a} (100.0)
Control (no treatment)	0.0	0.71^{d} (23.7)
CV (%)		**33.19**
SE ±		**0.29**

Notes: 1. Means within the same column followed by the same letter(s) are not significantly different at $P \geq 0.05$ using Student–Newman–Keuls (SNK) grouping.
2. Means of the powders were compared among themselves within the column.
3. Figures in the table are transformed (square-root) values from the original data, while figures in parentheses are percentages (%).
4. Initial number of insects used = 5 pairs.

Organoleptic test. Variations existed among treatments at 12 weeks post-treatment with regard to the seed quality and taste of Okpa (food) prepared from them (Table 8). Okpa food was prepared from these treated seeds of bambara groundnut at the end of the trial, and twenty healthy people were invited to taste it. Visual observations were made on seed quality, such as seed coat colour and texture. The Okpa food was served, and the people's responses were as follows: for the bambara groundnut seeds treated with seed powders of *Anogeissus leiocarpus* (AnoSP) at 10 g/100 g seed, 42.0% of the respondents rated the seed quality as destitute, 37.9% rated it as poor, 61.2% rated the okpa prepared from it as tasting poor, 22.6% rated it as fair, and 37.9% rated it as poor. AnoSP at 5.0 g/100 g seeds is also rated as poor in taste. For *Antidesma venosum* (AntSP) at a concentration of 10 g/100 g seeds, 30.5% of respondents rated the seed quality as poor, while 30.5% rated it as good; additionally, 56.3% of respondents rated the okpa prepared from it as poor, and 33.8% rated it as fair when tasted. At 5g/100g seeds, it was rated poor to taste.

Maranthes polyandra (MarSP) – respondents at both levels rated it as being excellent (58.8%), and 64.7% rated the okpa prepared from it as being palatable tasting, respectively.

Mitragyna inermis (MitSP): The respondents rated the seed quality as being very poor and the okpa prepared from it as being bad tasting.

Vitex madiensis (VitSP) was rated by 57.1% of respondents as having poor seed quality and by 30.8% as having satisfactory seed quality when using 10 g of seeds per 100 g. Okpa food prepared from *Vitex madiensis* seeds was rated as poor in taste by 52.4% of the respondents, while 39.1% rated it as fair. At a ratio of 5 g of seeds per 100 g, both the quality of the seeds and the taste of the Okpa prepared from them were rated poorly by respondents. Respondents rated the seeds and the Okpa prepared from them as poor at 5 g/100 g.

At actellic dust treatment, 58.8% of the respondents rated the seed quality as very satisfactory and the Okpa food prepared from it was rated as good in taste by 64.7% of the respondents. The untreated control received a 58.8% rating for seed quality as being poor, while the Okpa food prepared from it was rated as poor in taste by 64.7% of the respondents.

Table 8: Effect of Five Bioinsecticide Plant Powders on the Quality (Colour, Texture and Palatability) of Bambara Groundnut Seeds at 12 Weeks Post-Storage Treatment

Treatment	**Conc. (g)**	**Seed Quality Ratings (Colour and Texture)**				**Overall Assessment**	**Seed Taste/Flavour Ratings**			**Overall Assessment**
		Very Poor	**Poor**	**Good**	**Very Good**		**Poor**	**Fair**	**Good**	
Anogeissus leiocarpus seed powder	5.0	(58.8)	(9.2)	(9.2)	(9.2)	Very poor	(64.7)	(10.1)	(10.1)	Poor
	10.0	(42.0)	(37.9)	(20.5)	(9.2)	Poor	(61.2)	(22.6)	(10.1)	Poor
Antidesma venosum seed powder	5.0	(37.9)	(42.0)	(20.5)	(9.2)	Poor	(61.2)	(22.6)	(10.1)	Poor
	10.0	(9.2)	(51.1)	(30.5)	(9.2)	Poor	(56.3)	(33.8)	(10.1)	Poor
Maranthes polyandra seed powder	5.0	(9.2)	(9.2)	(9.2)	(58.8)	Very good	(10.1)	(10.1)	(64.7)	Good
	10.0	(9.2)	(9.2)	(9.2)	(58.8)	Very good	(10.1)	(10.1)	(64.7)	Good
Mitragyna inermis seed powder	5.0	(58.8)	(9.2)	(9.2)	(9.2)	Very poor	(64.7)	(10.1)	(10.1)	Poor
	10.0	(55.8)	(20.5)	(9.2)	(9.2)	Very poor	(64.7)	(10.1)	(10.1)	Poor
Vitex madiensis seed powder	5.0	(58.8)	(9.2)	(9.2)	(9.2)	Very poor	(64.7)	(10.1)	(10.1)	Poor
	10.0	(9.2)	(51.1)	(30.8)	(9.2)	Very poor	(52.4)	(39.1)	(10.1)	Poor
Actellic dust (Check)	2.0	(9.2)	(9.2)	(9.2)	(58.8)	Very good	(10.1)	(10.1)	(64.7)	Good
Control	0.0	(58.8)	(9.2)	(9.2)	(9.2)	Very poor	(64.7)	(10.1)	(10.1)	Poor

Note: Figures in the table are transformed (square-root) values from the original data, while figures in parentheses are percentages (%).

DISCUSSIONS

Five plant species' seed powdered treatments on adult mortality of *Callosobruchus maculatus* (L.) were found to increase with an increase in concentration levels generally, although in certain cases, the mortality with the 5.0 g treatment was on par with the 10.0 g concentration level and time of exposure to treatments. Grapefruit peel powder produced significantly higher levels of C. maculatus mortality at 10 g and 20 g/200 g seeds than sweet orange, lime orange, and lemon treatments, as well as the control, after 96 hours of treatment (Onu and Sulyman, 1997; Perzada et al., 2025).

Increasing the concentration levels beyond 10 g may enhance effectiveness, but bulkiness may make it too labourious to handle. Other likely hindrances to treatment potency may include differences in insect biotypes (Jacobson, 1983) and the stage of maturity of seeds used (Stoll, 1988; Oparake, 1997; Sedhu et al., 2026).

Higher concentrations of the treatments recorded lower oviposition in all plants under trials, although this effect varies from plant to plant. Ivbijaro (1983) reported that neem seed powders drastically reduced egg laying in female S. oryzae from 194 in the untreated control to only 9 and 3 at neem powder doses of 0.5 and 1.0/20 g maize grains, respectively. Generally, there were significant increases in the progeny development of C. maculatus from the F_1–F_3 filial generation in all the treatments and the development of *C. maculatus* from the F_1–F_3 filial generation in all the treatments with the exception of a few treatments. Although MarSP recorded high oviposition like other seed powders, it completely inhibited the development of F_2 and F_3 generations of *C. maculatus.* This phenomenon may be due to the oily nature of the seeds. According to Don-pedro (1989) and Bamayi et al. (2006), treatment with seed oil significantly suppressed progeny emergence due to its ability to either prevent the eggs from hatching or prevent the larvae and probably the pupae from completing their development in the cowpea grains. Furthermore, egg mortality: the physical properties of the oil coating block respiration, leading to increased egg mortality, rather than specific chemical effects. This increase in egg mortality is caused by the physical properties of the oil coating, which block respiration, the physical properties of the oil coating blocking respiration rather than by specific chemical effects.

There was a significant reduction in the potency of the botanical treatments after 12 weeks, which may be due to the exposure of the powders and the biodegradation of the active ingredients over time, as well as the volatility of the botanicals (OParaeke, 1997; Parmar et al., 2025).

The plant seed powders showed no adverse effects on seed qualities during the 4th and 8th weeks of treatment; however, by the 12th week, the potency was lost, and the F_3 filial generations caused significant damage during the 4th and 8th weeks of treatment until the potency was lost at the 12th week, and the F_3 filial generations became so destructive to some of the treated seeds. Some treatments suffered serious seed damage at 12 weeks of treatment, just like the untreated control, leading to weight loss and poor germination counts. The damage thereby reduced the quality of Okpa food prepared from the severely damaged seeds of Bambara groundnuts. Actellic dust treatment completely controlled the C. maculatus on the stored Bambara groundnut; its toxic effects on non-targets remain a significant concern (Matsumura, 1975; Bello et al., 2025).

CONCLUSION AND RECOMMENDATIONS

Conclusion

The study demonstrates that seed powders of locally available plants have considerable potential for managing *Callosobruchus maculatus* in stored Bambara groundnut. Although Actellic dust produced the highest overall mortality and the lowest seed damage, *Maranthes polyandra* consistently showed the most promising botanical performance. At both 5.0 and 10.0 g/100 g seed, MarSP substantially suppressed F_2 and F_3 progeny emergence, reduced weight loss and seed damage, and maintained high seed germination rates of 90.3% and 96.3%, respectively. The findings therefore establish *Maranthes polyandra* as a promising locally available botanical protectant for the medium- to long-term storage of Bambara groundnut. Its effectiveness, together with its favorable effect on seed quality and palatability, suggests that it could provide farmers with a practical alternative or complement to synthetic insecticides. However, the decline in botanical effectiveness over extended storage observed in the study indicates that further investigation is required before large-scale recommendation.

Recommendations

Based on the findings of this study, the following recommendations are made:

1. **Promotion of *Maranthes polyandra*:** Farmers should be encouraged to explore *Maranthes polyandra* seed powder, particularly at 5.0–10.0 g per 100 g of Bambara groundnut, as a promising botanical protectant during storage.

2. **Further field evaluation:** Larger-scale experiments should be conducted under farmers' storage conditions to confirm the effectiveness, consistency, and practicality of MarSP beyond the laboratory environment.

3. **Investigation of storage duration:** Further research should determine appropriate reapplication intervals because the effectiveness of the botanical powders declined with prolonged exposure, particularly after 12 weeks.

4. **Assessment of safety and quality:** Future studies should investigate the toxicity, residue levels, nutritional quality, and long-term effects of the powders on Bambara groundnut intended for human consumption.

5. **Optimization of dosage and formulation:** Research should examine different concentrations and formulations of *Maranthes polyandra* to determine the most effective dose while minimizing bulkiness and handling difficulties associated with higher quantities.

6. **Integrated pest management:** Botanical powders should be investigated as components of an integrated storage-pest management strategy, potentially in combination with resistant Bambara groundnut varieties and other appropriate non-chemical control methods.

7. **Conservation and utilization of indigenous plants:** Since several locally available botanicals remain underutilized, further research should identify and develop indigenous plant resources with insecticidal properties as sustainable options for smallholder farmers.

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