*Original Research Article*

Insecticidal efficacy of some botanicals against *Bruchus baudni* Caill (Coleoptera: Bruchidae) on *Senegalia Senegal* Seeds during storage

.

ABSTRACT

|  |
| --- |
| Our research shed light on the use of biopesticides and their responsibility to provide phyto-insecticides that are worthy of research into potential novel applications. There has been an increase in interest in using botanicals as a new insecticide in various sectors over the last several decades. A study was conducted at the Department of Crop Protection, Faculty of Agriculture, Bayero University, Kano, to determine the efficacy of potentials of seed oils and leaf powders of mahogany (*Khaya senegalensis* ) and Moringa (*Moringa oleifera*) for the control of *Bruchus baudni* on *Senegalia senegal* seeds during storage and determine the most effective concentration of the two botanicals for the control of B. baudni on S. senegal seeds and their germination potential in comparison with a conventional chemical insecticide (aluminum phosphide) was used as standard check. The treatments consisted of seed oils and leaf powders of K. senegalensis and M. oleifera at the rate of 2, 4, and 6 g/100 g seeds for leaf powders and 0.5, 0.75, and 1 m/100 g seeds for seed oils, and aluminum phosphide at 0.125 g/100 g, while the untreated (control) check was also set up along with the treatments. Data were collected on adult, larval, pupa mortality, residual toxicity, and seed germination. The results show that 100% mortality was achieved after 24 hours of exposure to the seed oils, while a significant increase in mortality of B. baudni was observed after 72 hours of exposure to mahogany and moringa leaf powders. More so, all had positive effects on seed germination. The LC50 concentration/dosage indicated that better protection of the S. senegal seeds could be achieved using 0.32% and 0.59% of the moringa and mahogany seed oils compared to the leaf powders 10.34%. Therefore, based on the present results, mahogany and moringa seed oil and leaves could be used in strategies to control B. baudni , especially as components of an integrated pest management strategy. |

*Keywords: Synthetic insecticide, Mahogany, Moringa, Bruchus baudni, Senegalia senegal seeds and Aluminum phosphide*

1. INTRODUCTION

Gum Arabic *(Senegalia Senegal)* (L) Britton is a small, thorny deciduous trees, native to north Africa. It is a drought resistant species suitable for dry tropics and grown mainly for its gum production in arid and semi- arid zones of African continent notably Sudan, Nigeria, Chad, [1]. Apart from the exudates the seed pods are used as fodder for goats, sheep and in Indian desert the seeds of the plant are consumed by local inhabitants in the form of vegetable as one of the constituents of the desert delicacy known as “Puncttikutta” [2; 3].

The gum produced has a wide range of multifunctional industrial uses. It is used as adhesive, binding, stabilizing in pharmaceutical, confectionery, beverage and cosmetics industries [4] and contributes significantly to the livelihood of the rural areas, national and global populace. Other uses of the crop include fencing, manufacturing of agricultural tools and handles, animal fodder, pods for tanin, timber production and nitrogen fixation into the soil [5]. Locally the gum is used in local ink preparation, pottery pigments, liquid gum, dyeing of textile and various tree parts are exploited for fuel wood, charcoal and herbal medicine [6]. The processed seeds of this plant are reported to have 37.2% protein, the highest among the seeds of 12 species of Acacia which is of medicinal value.

The seeds are very susceptible to insect infestation both in the field and store [7]. *Bruchus baudni* attacks *S. senegal* seeds in almost all countries of the North Africa [8]. The adults lay their eggs on the pod or seed surface, and the larva then burrows into the seed, developing and feeding on the endosperm before subsequently emerging as an adult [8, 9]. Development of *B. baudni* from egg to adults range from 45-56 days depending upon temperature and relative humidity [10]. *B. baudni* causes significant qualitative and quantitative losses in stored seeds ranged 30-50% in Nigeria and Ghana [9; 11; 12].

Synthetic insecticides are often used for protecting stored *S. senegal* seeds. However due to risk to the user, development of resistant pest strains, toxicity to non- target organisms and toxic residues left in the protected seeds. (Oparaeke and Bunmi, 2006; Obeng- Ofori and Dankwah, 2002). Therefore, the search for an alternative that can give satisfactory protection and yet be safe and ecologically friendly becomes imperative. Among promising alternatives are mahogany and moringa has low toxicity to mammals and it can be applied without specialized equipment. It kills insects by absorption of cuticular wax leading to water loss and desiccation (Korunic, 1998). Several mahogany and moringa powders and oils have been evaluated as grain protectant and many of them are now commercially available (Athanassiou *et al*., 2005). Moringa and mahogany have been found in Northern Nigeria in large deposits. It can be used to control *Sitophilus oryzae* (l.) Tribolium castaneum (Hebst.) and Phyzopertha dominica (F.) effectively on stored grains and its efficacy is comparable to many commercial chemicals (Kabir *et al*., 2013). Many researchers have shown the potentials of moringa and mahogany with other IPM compatible control method Athanassiou, 2006; Otitadum *et al*., 2015; Yang *et al*., 2010. Therefore, this study evaluated the efficacy of moringa and mahogany alone against *B. baudni* in stored *S. senegal*.

2. material and methods

The experiment was conducted in Entomology laboratory of the Department of Crop Protection of the Faculty of Agriculture, Bayero University Kano, during the months of March - July 2018. . The treatments consisted of two forms of plant botanicals (seed oil and leaf powder) obtained from *K. senegalensis*, *M. oleifera* at three (3) dosage/concentration levels (2, 4 and 6g/100g of seeds for leaf powders and 0.5, 0.75, and 1ml/100g of seeds for seed oils) and synthetic insecticide, Aluminum phosphide at 0.125g/100g seeds (standard check), with control (untreated) (Parugrug and Roxas, 2008; Musa, 2013) which were combined and laid out in a completely randomized design (CRD) with three replications.

**2.1 Insect Culture**

The initial cultures of *B. baudni* were obtained from an already infested *S. senegal* seeds at the gum Arabic plantation of the Rubber Research Institute of Nigeria (RRIN), Gashua, Yobe State. New generations were reared on clean uninfested *S. senegal* seeds in plastic containers under ambient temperature and relative humidity, to produce progeny insects of almost the same age which were used to conduct the experiments. The *S. senegal* seeds used were disinfested by putting in freezer for three days and later air dried for three hours in the laboratory.

**2.1.1 Preparation of *S. senegal* seeds**

*S. senegal* seeds were obtained from the Rubber Research Institute of Nigeria (RRIN), Gum Arabic plantation, Gashua, Yobe State, The fully matured pods of *S. senegal* were harvested by shaking the branches over a tarpaulin on the ground. After collection, the seeds were peeled, by hand, extracted and cleaned. *S. senegal* seeds with emerged holes or egg debris on the testa were considered infested and removed then the seeds were put in a freezer at temperature below 0oC for 5 days in order to kill and/ or prevent initial infestation of the seeds. The seeds were then removed from the freezer and laid out on the laboratory bench and covered with a screen so that the seeds could equilibrate for a period of three days and then kept until needed (Ileke *et al*., 2013).

**2.1.2 Preparation of the test plant material**

**2.1.2.1 *Seed oils***

Seeds of *K*. *senegalensis* and *M*. *oleifera* were obtained from matured fruits and were removed and dried under shade to reduce moisture content. These were ground with mortar and pestle and then warm water was added (10ml/kg of seed powder) to form a paste. The paste was then kneaded with hand and oil pressed out. This was filtered with a sieve (mesh size 5x 0.5m) to remove particles and oil was transferred into plastic bottles and stored for usage in the laboratory (Stoll, 1988).

**2.1.2.2 *Leaf Powder***

The leaves of *K. senegalensis* and *M. oleifera* were collected from the orchards of Audu Bako College of Agriculture, Danbatta, Kano State and BUK Orchard respectively. These were shade-dried to a crispy condition (Yusuf and Ahmed, 2005) and thoroughly pound in mortar with pestle. The pounded plant parts were passed through 40µm sieve to give fine powder. Each material was kept in separate plastic containers until needed.

**2.2 Treatments and Experimental Design**

The treatments consisted of two forms of plant botanicals (seed oils and leaf powders) obtained from *K. senegalensis*, *M. oleifera* at three (3) concentration levels (2, 4 and 6g/100g of seeds for leaf powders and 0.5, 0.75, and 1ml/100g of seeds for seed oils) and synthetic insecticide, Aluminum phosphide at 0.125g/100g seeds (standard check), while untreated (control) check was set up along with the treatments. The containers containing the treatments were shaken to ensure thorough admixture of *S. senegal* seeds with the treatments. The powders were allowed to settle down for about fifteen seconds before five pairs of adults *B. baudni* were added to each container. The containers were covered with mesh cloths fastened with rubber bands, labelled and kept at ambient temperature and relative humidity. Treated containers and untreated controls were laid out in completely randomized design and replicated three times (Parugrug and Roxas, 2008; Musa, 2013).

**2.3 Bioassay**

Hundred grams’ seeds of *S. senegal* were weighed in plastic containers (100cc) and admixed separately with 2, 4.and 6g/ 100g seeds for leaf powders and 0.5, 0.75 and 1ml /100g seeds for seed oils, Aluminum phosphide at 0.125g 100g seeds was used as standard. Untreated seeds served as control then thoroughly mixed with the various concentrations of the two forms of plant botanicals. Thereafter, five (5) pairs of newly emerged adults of *S. senegal* seed borer were introduced into each container. These containers were closed by muslin cloth and tightly secured by rubber band. The experiment was carried out at a room temperature. Mortality was assessed at 24, 48 and 72 hours after treatment. Adult insects were considered dead when probe and there were no movements. The experiment set up was kept undisturbed on the laboratory bench for F1 and F2 progeny emergence. After three months, seed damage weight loss was determined.

**2.3.1 Adult mortality**

 Samples of hundred (100) grams of S. *senegal* seeds in a plastic container were thoroughly mixed with 2, 4 and 6g of the leaf powders, 0.50, 0.75 and 1.00 ml of the seed oils, 0.125g of Aluminum phosphide (check) and control (0.00g). Five pairs of unsexed newly emerged 2-3 days old *B. baudni* were introduced into the container and then covered with a muslin cloth and tied with a rubber band. These were kept on Laboratory benches. Number of dead insects in each treatment and replicates was removed, counted and recorded at day 1, 2, and 3 after infestation. Insects were probed three (3) times with a tip of pen to confirm mortality.

**2.3.2 Residual Toxicity**

Data on residual toxicity was collected by counting the number of dead insects from the F2 progeny reproduced by the parents that was introduced into the treated seeds. The data were collected 60 days after treatment as adopted by Abduljalal *et al*., (2011). In a similar set up, biocide effect of the test materials was conducted to assess their larvicidal and pupidal efficacy.

**2.3.3 Larval Mortality**

Larval mortality was obtained by opening the seeds with a scalpel and a pair of forceps at the end of adult emergence and dead larvae inside the seeds were counted (Arong *et al*., 2011).

**2.3.4 Pupal Mortality**

Similarly, pupal mortality was obtained by opening the seeds with a scalpel and a pair of forceps at the end of adult emergence and dead pupae inside the seeds were counted (Arong *et al*., 2011),

**2.3.4 Seed germination test**

Prior to sowing, the seeds of *S. senegal* were soaked in tap water and kept at room temperature for 48 hours in order to break the seed dormancy and enhance germination (Ojiekpon, *et al*., 2011). The percentage germination of treated and untreated seeds was tested four months after treatment with botanicals and subsequent infestation by *B. baudni*. Fifteen seeds from treated and untreated treatment were then randomly selected and placed separately on a moistened Whatman filter paper in 9cm Petri dishes, labeled and kept on laboratory benches exposed to sunlight for one week (ISTA, 1996; Mathur and Konsdal, 2003). Three (3) days after sowing the first germination count were recorded and then at 2 days’ intervals (i.e. day 5 and 7 respectively). Germination was assessed as percentage of seeds that produced normal seedlings (ISTA, 2006). Three replications were maintained.

**2.4 Data Analysis**

Data on adult mortality were first corrected for mortality in the controls using the Abbotts (Abbott, 1925) formula. Data on the corrected mortality, seed damage, weight loss assessment and germination were transformed using arc sine transformation while data on number of progeny were square root transformed. these were then subjected to one–way analysis of variance (ANOVA) using Genstat statistical software, where significantly different treated means at P<0.05 were separated by student Newman Keuls.

3. results and discussion

**3.1 Effects of plant seed oils on Adult Mortality of *B. baudni* at 24, 48 and 72 hours’ exposure on *S. senegal* seeds**

The results revealed that the mean mortality of adult *B. baudni* at 24, 48 and 72 hours on *S. senegal* seeds treated with *M. oleifera a*nd *K. senegalensis* seed oils were significantly *(P = 0.05)* different with the control (Table 1). More so, all the treatments, *M. oleifera a*nd *K. senegalensis* and the synthetic insecticide were similar while the control treatment recorded the lowest insect mortality (0.00, 1.2 and 4.5) at all levels and HAT.

**.**

**Table 1: Adult Mortality of adult *B. baudni* at 24, 48 and 72 hours’ exposure on *S. senegal* seeds treated with some bio-pesticides.**

|  |  |
| --- | --- |
|  | **Percentage Adult Mortality (Hours)** |
|  | **Moringa Seed Oil** |  | **Mahogany Seed Oil** |
| **Concentration** **(ml/100g seeds)** | **24** | **48** | **72** |  | **24** | **48** | **72** |
| 0.5 | 71.5 (57.70a) | 89.3 (70.78a) | 89.3 (70.78a) |  | 36.7 (32.71a) | 54.7 (47.71a) | 62 (51.93a) |
| 0.75 | 80.4 (63.73a) | 79.7 (63.22a) | 97.3 (80.63a) |  | 72 (58.08a) | 72 (58.08a) | 93.3 (75.00a) |
| 1.00 | 94.9 (76.92a) | 94.9 (76.92a) | 100 (90.00a) |  | 88.4 (70.07a) | 88.4 (70.07a) | 96.3 (78.93a) |
| Aluminum Phosphide | 75 (59.00a) | 93.3 (75.00a) | 100 (90.00a) |  | 88.4 (70.07a) | 98.8 (83.86a) | 100 (90.00a) |
| Control  | 0.00 (0.00b) | 1.2 (6.14b) | 4.5 (12.29b) |  | 0.00 (0.00b) | 0.00 (0.00b) | 1.2 (6.14b) |
| SE± | 9.502 | 11.196 | 7.127 |  | 12.137 | 11.679 | 10.933 |

Figures in parenthesis are arc sine values to which SE are applicable. Means followed by same letter(s) within same column are not significantly different at *P=0.05* according to SNK test.

**3.2 Effects of plant leaf powders on Adult Mortality of *B. baudni* at 24, 48 and 72 hours after exposure to *S. senegal* seeds**

The results presented in table 2 shows the effects of some botanicalsk on adult mortality of *B. baudni* at 24, 48 and 72 HAT. The moringa leaf powder had significantly *(P = 0.05)* affected *B. baudni* mortality at all levels and HAT. Higher mortality was recorded at 72 and 48 HAT although; similar at all levels including the synthetic insecticide which recorded 100% mortality. However, at 24 HAT, the synthetic insecticide had the highest *(P = 0.05)* mortality compared to other concentrations, followed by 6g/100g while 2g/100g seeds treatment was lower while the untreated control had the lowest mortality. Moreover, mahogany leaf powder had significantly *(P = 0.05)* affected *B. baudni* mortality at all levels and HAT (Table 2). Among the leaf powder levels, 6g/100g seeds recorded the highest mortality across hours after treatment especially at 48 and 72 HAT although similar with other levels (2 and 4g/100g seeds) and HAT. Nonetheless, the synthetic insecticide treatment proved to have the highest mortality compared to the plant botanicals and was similar to 2g/100g seed treatment. The control treatments had the lowest mortality across the levels and hours after treatments (Table 2).

The present study confirms that mixing *S. senegal* seeds with plant leaf powder caused high mortality of *B. baudni* compared to control*.* However, the findings of Bhagat and Tripatri (1989) and Lucy *et al* (2016) contrasted with these as they reported an increasing efficacy of neem leaf powder as concentration increased from 1-3 g/100g seeds. On theother hand, the plant extracts might have interfered with the normal embryonicdevelopment by suppressing hormonal andbiochemical processes. Similar physiological interferences were observed by Ofuya *et al*. (1992) and Jayakumar *et al*. (2003).This finding supports previous research works that the effects of the mortality of *B. baudni* depended on the type of plant leaf powder and the concentration used. After treatment, there was direct relationship between number of bruchids killed and quantity of neem powder applied Jayakumar *et al*. (2003).

The results had also clearly shows the dependence of insecticidal activity on rate of application of insecticidal neem leaf powder. Similar findings were previously reported by Golob *et al* (1982); Sharaby (1988); Misari and Usman (1990). More so, Bhagat and Tripathi (1989) had earlier contrasting report that the efficacy of neem leaf powder increased with the increase in the concentration from 1 to 3g/100g seed grain. The results here confirmed the findings of Adedire and Akinneye, (2004) who reported that there is potential in plant product for the control of *C. maculatus*. These findings further support the ideas of (Ogundipe, 1998) who also proved that, plants generally produce many secondary metabolites which constitute an important source of pesticides, microbicides and many pharmaceutical drugs. This further agrees with the findings of Athanassiou, (2006), who reported that *S. oryzae* progenies emerged in stored wheat treated with beta cyfluthrin applied in combination with diatomaceous earth where 100% mortality of exposed adults were recorded. The effectiveness of oil extract from *M.* *oleifera* roots against *C. maculatus* could be due to its pungency (Panchal *et al.,* 2011). Yusuf and Ahmed (2005) also reported that the rate of 8g/100g of grain reduced infestation at 42 and 63 DAT.

Table 2: **Adult Mortality of *B. baudni* at 24, 48 and 72 hours after exposure to *S. senegal* seeds treated with plant leaf powder bio-pesticides.**

|  |  |
| --- | --- |
|  | **Percentage Adult Mortality (Hours)** |
|  | **Moringa Leaf Powder** |  | **Mahogany Leaf Powder** |
| **Concentration** **(ml/100g seeds)** | **24** | **48** | **72** |  | **24** | **48** | **72** |
| 2 | 6.6 (8.86c) | 40.4 (39.47b) | 61.1 (51.44a) |  | 10 (15.00ab) | 50.5 (45.29b) | 62 (51.93b) |
| 4 | 13.3 (17.21c) | 43.7 (41.40b) | 74.1 (59.44a) |  | 13 (21.14ab) | 30 (33.21b) | 67.7 (55.36b) |
| 6 | 50 (45.00b) | 69 (56.15b) | 83.6 (66.14a) |  | 36.1 (36.93a) | 60.6 (51.14b) | 63.9 (53.07b) |
| Aluminum Phosphide | 96.3 (78.93a) | 100 (90.00a) | 100 (90.00a) |  | 41.4 (40.07a) | 97.6 (81.14a) | 100 (90.00a) |
| Control  | 0.00 (0.00c) | 1.2 (6.14c) | 2.4 (8.86b) |  | 0.00 (0.00b) | 0.00 (0.00c) | 0.00 (0.00c) |
| SE± | 7.802 | 8.803 | 10.965 |  | 6.745 | 6.520 | 6.227 |

Figures in parenthesis are arc sine values to which SE are applicable. Means followed by same letter(s) within same column are not significantly different at P=0.05 according to SNK test.

**Table 3: Mean germination indices of *S. senegal* seeds treated with some plant botanical seed oils**

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
|   |  |  |  | **Germination Indices** |  |  |  |  |
|  | **Moringa Seed Oil** |  | **Mahogany Seed Oil** |
| **Concentration (ml/100g seeds)** | **% G** | **G.I** | **G.R.I** | **STL (cm)** | **RTL (cm)** |  | **% G** | **G.I** | **G.R.I** | **STL (cm)** | **RTL (cm)** |
| 0.5 | 94.2 (76.03a) | 5.16a | 0.07 | 2.29a | 2.82a |  | 88.9 (70.52a) | 4.82ab | 0.07 | 3.12a | 2.08a |
| 0.75 | 85.2 (67.39a) | 5.14a | 0.08 | 2.07a | 2.68a |  | 87.5 (69.26a) | 4.38ab | 0.06 | 2.77a | 1.97a |
| 1.00 | 95.9 (78.25a) | 5.22a | 0.07 | 2.00a | 2.62a |  | 91.6 (73.14a) | 5.44a | 0.07 | 2.84a | 2.26a |
| Aluminum Phosphide | 98.5 (82.87a) | 4.99a | 0.06 | 2.28a | 2.87a |  | 94.7 (76.73a) | 4.71ab | 0.06 | 2.87a | 2.10a |
| Control  | 0.57 (4.32b) | 1.67b | 0.13 | 0.00b | 1.00b |  | 1.2 (6.14b) | 1.67b | 0.09 | 1.00b | 1.00b |
| SE± | 7.588 | 0.793 | 0.058 | 0.082 | 0.173 |  | 10.356 | 0.808 | 0.042 | 0.124 | 0.085 |
|  |  |  |  |  |  |  |  |  |  |  |  |

Figures in parenthesis are arc sine values to which SE are applicable. Means followed by same letter(s) within same column are not significantly different at P=0.05 according to SNK test. **%G=** Germination Percentage**, GI=** Germination Index**, GRI=** Germination Rate Index**, STL=** Shoot Length**, RTL=** Root Length.

**3.3 Effect of plant seed oil on the germination indices of *S. senegal* seeds**.

The results had revealed that the effects of essential oils of moringa and mahogany on the germination indices of *S. Senegal* 90 days after treatments were significant (*P = 0.05*). Generally, Mahogany oil treatments and the synthetic insecticide had statistically (*P = 0.05*) recorded similar effects across all the oil concentrations on all the germination indices of *S. senegal* which are different from the control treatment (Table 5). However, the treatments across all concentrations had no significant effect on the germination rate index (GRI).

These results revealed that the treatments did not affect the germination indices of the S. senegal seeds adversely and had corroborated the work of Obengofori and Dankwah (2002) who showed that neem leaf powder and actellic 25 EC did not affect the germination of Bambaranut seeds after 90 days of treatments. This result also is in agreement with Mariappan *et al* (2013) that seeds protected with Jatropha curcas pelleted with pungan leaf powder and Pongamia pinna seeds pelleted with neem leaf gave high germination percentage due to effective protection from fungal and insects, thus increase in percent germination of the treated seeds. The present research, agreed further with the findings of (Gupta *et al*, 1989; Lucy *et al* 2016), that, neem dosage did not impair germination. In fact, rice seedlings raised from seed treated with 2.5 seed kernel extract or with 2% neem cake were more vigorous and had higher root and shoot growth indices and dry weight than those germinations from the untreated seeds (Abdulkareem *et al*., 1989; Karshon, 1975). On the other hand, Ranasinghe and Dharmasena (1989) reported poor percentage germination when cowpea was treated with neem oil at 10 days before testing but significantly increased at 30 days.

**3.4 Effect of plant leaf powder on the germination indices of *S. senegal* seeds.**

Result of mean germination indices of *S*. *senegal* seeds treated with some plant leaf powders is shown in table 5. All the germination indices (% G, G.I, G.R.I, STL and RTL) all level of concentrations including the synthetic insecticide were significantly (*P = 0.05*) different with the control check, however, 6g/100g seeds concentration of moringa leaf powder was higher than other concentrations including the chemical insecticide. More so, as regards the germination index, all the moringa powder treated seeds were significantly *(P = 0.05)* the same where the synthetic insecticide recorded the highest germination index with the control having the lowest.

Similarly, seeds exposed to mahogany leaf powder at all concentrations had recorded similar trends as in moringa leaf powder except on the germination index where the concentrations of mahogany leaf powder at 2 and 6 g/100g seeds that recorded significantly (*P = 0.05*) the same and higher germination index. However, 1ml concentration of the mahogany oil recorded the highest GI and was significantly (*P = 0.05*) different with other concentrations (0.5ml, 0.75ml and the synthetic insecticide) while the control was the lowest. Moreover, the mahogany oil at all concentrations were statistically (*P = 0.05*) significant and similar including the synthetic insecticide on shoot and root length, both control checks were the lowest. The germination rate index was not significantly affected by the mahogany oil treatment at all concentrations.

**Table 4: Mean germination indices of *S. senegal* seeds treated with some plant botanical leaf powders**

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
|   |  |  |  | **Germination Indices** |  |  |  |  |
|  | **Moringa Leaf Powder** |  | **Mahogany Leaf Powder** |
| **Concentration (g/100g seeds)** | **% G** | **G.I** | **G.R.I** | **STL (cm)** | **RTL (cm)** |  | **% G** | **G.I** | **G.R.I** | **STL (cm)** | **RTL (cm)** |
| 2 | 93.8 (75.63a) | 4.19b | 0.06a | 2.11a | 2.57a |  | 85.4 (67.50a) | 4.15b | 0.06a | 1.92a | 2.63a |
| 4 | 80.7 (63.99a) | 4.31b | 0.06a | 1.96a | 2.33a |  | 89.5 (71.12a) | 5.02a | 0.07a | 1.98a | 2.72a |
| 6 | 99.24 (85.00a) | 4.59b | 0.06a | 2.24a | 3.00a |  | 71.3 (57.59a) | 4.03b | 0.07a | 2.14a | 2.97a |
| Aluminum Phosphide | 98.5 (82.87a) | 5.61a | 0.07a | 2.19a | 2.87a |  | 98.5 (82.87a) | 5.37a | 0.06a | 2.25a | 2.87a |
| Control  | 0.57 (4.31b) | 0.00c | 0.00b | 1.00b | 1.00b |  | 0.00 (0.00b) | 0.00c | 0.00b | 1.00b | 1.00b |
| SE± | 8.027 | 0.222 | 0.006 | 0.083 | 0.184 |  | 7.122 | 0.253 | 0.009 | 0.092 | 0.176 |

Figures in parenthesis are arc sine values to which SE are applicable. Means followed by same letter(s) within same column are not significantly different at P=0.05 according to SNK test. **%G=** Germination Percentage**, GI=** Germination Index**, GRI=** Germination Rate Index**, STL=** Shoot Length**, RTL=** Root Lengt

**3.5 Estimated LD50 of type and concentration of plant products on adult mortality of *B. baudni***

The LD50 values, 95% confidence limits and other regression analysis parameters of the tested bio-pesticide formulations are given in table 5. Moringa seed Oil was the most superior with LD50 value of 0.32%, followed by MHSO with LD50 values of 0.59. Moreover, MLP and MHLP showed toxicity with LD50 values of 10.34 and 10.34%, respectively.

The results confirm that exposing *S. senegal* seeds to plant oils had no effect on the germination indices. Singh and Yadav, (2003), reported no effect on germination of gram seeds treated with neem, karany and mustard, 90, 150, 210 days after treatment. GRI and STL performed best at all levels, thus seed germination indices of *S. senegal* had improved due to the protection by these oils. None of the treatments apparently reduced the seed germination indicating that these plant oils can be used safely for the control of *B. baudni*. The current study finds support from the work of streeramaiah and Bemmegoude (1992). Who reported higher germination of cheek pea seeds treated with neem oil. Lastly the germination indices of *S. senegal* seeds treated with various concentrations of moringa and mahogany leaf powders gave the best results and these were similar with Aluminum phosphide.

**Table 5: Estimated LD50 of type and concentration of plant botanicals on adult mortality of *B. baudni* on stored gum Arabic seeds**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Bio-pesticides** | **LD50a (%)** | **95% Confidence Limits (%)** | **Slope ± (SE)b** | **Intercept ± (SE)c** | **(χ2)d** |
| **Lower Limit** | **Upper Limit** |
| MSO | 0.32 | 0.009 | 0.449 | 4.58 ± 1.98 | 7.25 ± 0.48 | 0.192 |
| MHSO | 0.59 | 0.450 | 0.682 | 4.42 ± 1.18 | 6.01 ± 0.23 | 0.107 |
| MLP | 10.34 | 6.257 | 1958.773 | 1.99 ± 0.86 | 2.97 ± 0.55 | 1.488 |
| MHLP | 10.34 | 6.257 | 1958.773 | 1.99 ± 0.86 | 2.97 ± 0.55 | 1.488 |

Concentration/dosage causing 50% mortality after 24 h. of treatment; b: Slope of concentration mortality regression line; c: Intercept of regression line; d: Chi square value.

4. Conclusion

The present findings show that all the treatments were better than the control. Mahogany and Moringa seed oils performed better than the leaf powders irrespective of their concentrations and statistically similar with the chemical insecticide (Aluminum phosphide). However, among the leaf powder concentrations, better protection of the *S. senegal* seeds was achieved with Moringa and Mahogany at 6g dosage rate. Effective toxicity on adult insects, significant reduction in oviposition, and inhibition of progeny emergence was achieved by using both the Moringa and Mahogany seeds oils and leaf powders on germination of the *S. senegal* seeds. The study recommended that mahogany and moringa seed oils at 0.5ml/100g seeds and leaf powders at 6g/100g seeds could be employed for the control of *B. baudni* on stored *S. senegal* seeds in the study area. Also *S. senegal* seeds could be protected using 0.32% and 0.59% of the LC50 dosage of moringa and mahogany seed oils respectively while 10. 34% of the leaf powder in both the two plant products.

References

1. FDA. Base Line Survey on Gum Arabic Production. Monograph by Federal Department of Agriculture in Collaboration with Rubber research Institute of Nigeria and Forestry Research Institute of Nigeria, 2002.

1. Abdullahi, A. Report on Survey of Selected Agricultural Raw Materials in Nigeria. Document Prepared for the Nigerian Raw Materials Research and Development Council (RMRDC), Abuja Nigeria, 2004
2. Nisha, Patel, S.K., Jindal, Majit singh and Anjly Pancholy. Bruchid Infestation in Pod and Seed in Exotic Collections of *Acacia Senegal* (L.) Willd. In the Thar Desert. *Anals of Arid Zone*. 2008; 47(1): 55-61.
3. Navarro, A. Sudan’s Manna from Heaven and Strategic Weapon, AFP. Archived 28 May 2013 at the Way Back Machine, 2008.
4. Aghughu, O. Personal Tipping’s from Gum Arabic Literature Collected During the Visit of E. African Rubber Research Institute, Nigeria,1995.
5. Food and Agricultural Organization (FAO), Quality Control of Gum Arabic in Nigeria (Project TCP/ RAF/ 4557 Document) 1996.
6. Obeng-ofori, D. and Dankwah, J. A. Biological Effects of Four Protectants applied to Stored Bambara Groundnut against Infestation by *Callosobruchus maculatus* (Fab.) (Coleoptera: Bruchidae). *Journal of Ghana Science Association*. 2002; 4(2): 41-51
7. Appleby, J.H. and Credland, P.F. Botanical and Polymorphism in Callosobruchus subinnotatus (Coleoptera: Bruchidae). *Bulletin of Entomological Research*, 2001; 91: 235-244.
8. Haines, C.P. Insects and Arachnids of Tropical Stored Products: Their Biology and Identification (2nd edition). National Resources Institute, Chatha. UK. 1991; 246pp.
9. Lale, N.E.S. Stored Product Entomology and Acarology in Tropical Africa, First Edition. Mole Publications uguri, Nigeria, 2002; 204pp.
10. Operaeke, A. M. and Bunmi, O. J. Insecticidal Potential of Cashew (*Anacardium occidentale* L.,) for Control of Beetle *Callosobruchus subinotatus* (Pic.) (Bruchidae) on Bambara groundnut (*Voandzia subterranea*) (L.). Verdc. *Archives of Phytopathology and Plant Protection*, 2006; 39: 247- 251.
11. Golob, P., Moss, C., Devereau, A., Goodland, A. D., Andan, F. H., Atarigya, J. and Tain B.M.D. Improvements in the Storage and marketing Quality of Grain Legumes: Final Technical report. NRI Report 2417. Project R 6503. Natural Resources Institute Chatham Maritime Kent. 1999; U.K. 246pp.
12. Korunic, Z. Diatomaceous Earths, a Group of Natural Insecticides. *Journal of Stored Products Research*, 1988; 34: 87-97.
13. Athanassiou, C. G., Kavallierators, N. G., Tomanovic, Z. (2006). Factors Affecting the Insecticidal Efficacy of the Diatomaceous Earth Formulation Silicosec Against Adults of the Rice weevil, *Sitrophilus oryzae* (L.) (Coloeptera: Curculionidae). *Applied Entomology and Zoology*: 41: 201- 207.
14. Kabir, B.G.J., Lawan M. and Jidda M. B. Bioactivity of Raw Diatomaceous Earth against *Rhyzopertha dominica* Fab. (Coleoptera: Bostrichidae). Effect of Grain Type Dose Rate and Exposure Period. *Journal of Agriculture and Veterinary Science*. 2013; 4:44-59
15. Otitodun, G. O., Opit, G.P., Nwaubani, S.I., Okonkwo, E.U. and Gautam, S.G. Efficacy of Nigerian- Derived Diatomaceous earh, Botanical and Riverbed Sand Against *Sitophilus oryzae* and *Rhyzopertha dominica* on Wheat. *African Crop Science Journal. 2015;* 23: 279-293
16. Yang, N.W., Li, A. L., Wan, F. H., Liu, W. X and Johnson, D. Diamaceous Earth Enhances the Toxicity of Garlic Allium sativum. Essential Oils against Stored Product Pests. *Journal of Stored Products Research,* 2010; 46: 118-123.
17. Parugrug, M. L. and Roxas, A.C. Insecticidal Action of Five Plants against Maize Weevil, *Sitophilus zeamais* Motsch, (Coloeptera: Curculionidae). *KMITL Science. Technolology S.*, 2008; 8(1): 24-38.
18. Musa, A. K. Influence of Plant Powders on Infestation by Adults and Larvae of Khapra Beetle, *Trogoderma granaria* Everts (Coloeptera: Dermestidae) in Stored Groundnut. Australian. *Journal of Basic and Applied Sciences*, 2013; **7**(6): 427-432.
19. Ileke, K.D. Bulus, D.S. Aladegoroye, A.Y. Effects of Three Medicinal Plants Products on Survival, Oviposition and Progeny Development of Cowpea Bruchids. *Callosobruchus maculatus* (fab.) [Coloeptera: Chrysomelidae]. Infesting, Cowpea Seeds in Storage. *Jordan Journal Biology Sci*ence, 2013; **6(**1): 61-66.
20. Stoll, G. **Natural Crop Protection Based on Local Farm Resource in the Tropics and Sub-Tropics.** 3rd Edition, Weikerssheim, Germany, Margraf Publishers, Scientific Books; 188pp 1988.
21. Yusuf, S. R., and Ahmed, B. I. Potential of *Khaya Senegalensis* on *Callosobruchus maculatus. Journal of Stored Product Research* 2005; 13: 19-23.
22. Arong, G.A., Imandeh, G.N., Utsu, A.A. and Shaa, K.K. The Influence of Food Type on Larval Growth in *Musca domestica* and *Lucilia sericata* (Diptera) in Calabar, Nigeria. *World Journal Science Technol.* 2011; 1: 73-77.
23. Abbott W.S. A Method of Computing the Effectiveness of an Insecticide. *Journal of Economic Entomology*, 1925; **18**: 265-267.
24. Boateng B.A., Kusi F. Toxicity of Jatropha Seed Oil to Callosobruchus maculatus (Coleoptera: Bruchidae) and its Parasitoid Dinarmus basalis (Hymenoptera: Pteromalidae). *Journal of Applied Science Research*, 2008; 4: 945-951.
25. Nepolean, P., Anitha, J., Renitta, R. E. Isolation, Analysis and Identification of Phytochemicals of Antimicrobial Activities of Moringa oleifera, *Current Biotica*, 2009; 3(1), 33-39.
26. Jayakumar M, Elumalai K, Jeyasankar A, Raja N, Ignachimuthu S. Efficacy of crude extracts of *Hyptis suaveolens* and *Melochia chororifolia* on pulse weevil *Callosobruchus maculatus* (F.) (Coleoptera: Bruchidae). Proceedings in Biological Control of Insect Pests. 2003; 219- 223.
27. Misari, S. M. and Usman, S. A. Evaluation of Neem Products and Synthetic Insecticides for the Control of Rust Red Flour Beetle, *Tribolium castaneum* Herbst. On Stored Groundnuts. In Legumes and Oilseeds Research Samaru, Zaria. Cropping Scheme Meeting, 1990; Pp.19-21.
28. Ebadollahi, A. Plant Essential Oils from Apiaceae Family as Alternatives to Conventional Insecticides. Ecological Balkanica 2013; 5(1):149-172.
29. Bhagat, O.P. and Tripathi, V.K. The Efficacy in Combination with Tulsi Against *Rhyzopertha dominica* (F.) in Stored Maize, Neem Neemsletter. 1989; 6 (4). Indian Agricultural Research Institute, New Delhi.
30. Lucy, E., Aliyu, M. and Ojiekpon, I.F. Effect of Neem Powders (*Azadirachta indica* A. Juss) on the Preservation of Gum Arabic (*Acacia senegal* L. Willd) Infested with *Bruchus baudni* (Caill) in Gashua, Yobe State Nigeria. *Journal of Agriculture and Food Environment* 2016; **3**(2): 109-121.
31. Ofuya T. I, Okoye BC, Olola A. S. Efficacy of a crude extract from seeds of *Monodora myristics* (Gaem.) Dunal as surface protectant against *Callosobruchus* *maculatus* (F.) attacking legume seeds in storage. *Journal. Stored Product Researche.,* 1992; **31**(3): 221 -228.
32. Sharaby, A. (1988). Evaluation of Some Myrataceae Plan Leaves as Protectants Against the Infestation by *Stitophilus oryzea* L. and S. granaria L. *Insect Science and its Application* 9 (4):465-468.
33. Adedire, C.O. and Akinneye, J.O. Biological activity of tree marigold, *Tithonia diversifolia*, on cowpea seed bruchid, *Callosobruchus maculatus* (Coleoptera: Bruchidae). *Annals of Applied* *Biology* 2004; 144(2):185-189
34. Udo, I. O. and Epidi, T.T. Biological Effect of Ethanolic Extract Fractions of *Ricinodendron heudelotii* (Baill) Pierre ex Pax Against *Sitophilus zeamais* (Motschulsky) and *Callosobruchus maculates* Fabricius on Stored Grains. *Africa. Journal. Agriculture. Research.*, 2009, 4: 1080-1085.
35. Wongo, L. E. Biological Activity of Sorghum Tannin Extracts on the Stored Grain Pests *Sitophillus oryzae* (L.), *Sitotroga cerealella* (Olivier) and *Tribolium castaneum* (Herbst). *Insect* *Science and its Application,* 1998, **18**: 17-23.
36. Makanjuola W. A. Evaluation of Extracts of Neem (*Azadirachla indica* A. juss) for the Control of Some Stored Pests. *Journal Stored Product Research*, 1989, 25:231-237
37. Tanzubil, P. B. Control of Some Pests of Cowpea (*vigna unguiculata* L. Walp.) with Neem (*Azadirachta indica* A. Juss.) In Northern Ghana. Tropical Pest Management, 1991, 37(3): 216-217.
38. Lale N.E.S., Abdulrahman H.T. Evaluation of Neem (*Azadirachta indica* A. Juss) Seed Oil Obtained by Different Methods and Neem Powder for the Management of *Callosobruchus maculatus* (F.) (Coleoptera: Bruchidae) in Stored Cowpea. *Journal of Stored Products Research*, 1999, 35: 135-143.
39. Lale N.E.S, Mustapha A. Potential of combining neem (*Azadirachta indica* A. Juss) seed oil with varietal resistance for the management of the cowpea bruchid, *Callosobruchus maculatus* (F.). *Journal stored* *Product Research*., 2000, **36**: 215-222.
40. Ivbijaro, M. F. Preservation of Cowpea, *Vigna unguiculata* L. (Walp), with the Neem Seed, *Azadirachta indica* A. juss. Protection Ecology, 1983, 5 (2): 177-182.
41. Babu T R, Reddy V S and Hussaini S H. Effect of Edible and Non-Edible Oils on the Development of Pulse Beetle (*Callosobruchus chinensis* L.) and on Viability and Yield of Mungbean (*Vigna radiata* (L.) Wilzek). *Tropical Science*, 1989, **29**(3): 215-220
42. Don-Pedro K.N. Mechanisms of Action of Some Vegetable Oils Against *Sitophilus zeamais* Motsch (Coleoptera: Curculionidae) on Wheat. *Journal Stored Products Research,* 1989, 25: 217-223.
43. Copping L. G. and Menn J. J. Biopesticides: A Review of Their Action, Applications and Efficacy. *Journal of Pest Management Sciences,* 2000; 56: 651- 679.
44. Stoll, G. Natural Crop Protection in the Tropics: Letting Information Come to Life. 2nd Enlarged Edition. Margraf Verlag, 2000.
45. Ekesi, S.. Ash from Cooking Fire Synergises Efficacy of the Entomopathogenic Fungus, *Metarhizium anisopliae* against Four Major Stored Product Insect Pests. *Nigeria journal of Entomology*, 2005; 22. 64-75
46. Wudil, B. S.Effects of the Essential Oils of Mahogany, *Khaya senegalensis* A. Juss. and Neem, *Azadiracta indica* A. Juss. on Cowpea for the Control of Pod Sucking Bugs Complex (*Clavigralla spp*) in Bauchi, Nigeria. *Techno Science Africana Journal*. 2013; **8 (1):** 46 – 52
47. Wudil, B. S., Yusuf, S. R., Ahmed, B. I. and Sanda, N. B. Potentials of Two Bio-pesticides in the Management of *Memalurothrips sjostedti* (Trybom) on Cowpea in the Northern Guinea Savannah of Nigeria. *Dutse Journal of Agriculture and Food Security* 2015; 2 (2)1-10.