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# Powders of *Newbouldia laevis* as protectants of cowpea seeds against infestation by *Callosobruchus maculatus* (Fab.) for poor resource farmers

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ABSTRACT

The efficacy of the powders of *Newbouldia laevis (*Seem) was tested as grain protectants against infestation by *Callosobruchus maculatus* (Fab.) on cowpea (*Vigna unguiculata* L. (Walp) stored for three months at ambient temperature of 280C± 20C and 70 ± 5% relative humidity. Powder from the leaves, stem, root and wood ash were tested at 0.0g (control), 0.1g, 0.2g, 0.3g, 0.4g and 0.5g per 20g of cowpea seeds. Mortality, oviposition and adult emergence of *C. maculatus* as well as seed damage and weight loss of cowpea varied over the period of storage. 100% mortality of adult beetles was achieved at higher concentrations (0.4 and 0.5g) of the powders within 96hrs of application. This was significantly different ($p<0.05$) from the control and those obtained at lower concentrations. Mortality however decreased over the three months period of storage at lower concentrations while higher concentrations maintained their effectiveness. Oviposition and adult emergence of C. maculatus were significantly higher ($p<0.05$) in the control than in treated seeds throughout the period of storage. More eggs were laid at lower concentrations and consequently the percentage adult emergence was higher. Oviposition and adult emergence increased from one to three months of storage. Seed damage and weight loss were significantly higher ($P<0.05$) in the control than in treated seeds throughout the period of storage. Therefore, the powder of *N. laevis* could be used to protect cowpea seeds stored for a short period against infestation by *C. maculatus* and higher concentrations is needed for long-term storage.

## INTRODUCTION

Nigeria domestic food production is low as it is not enough to meet the national food demand; and the little that were produced are facing losses because of inadequate processing techniques and infestation by stored product insect pests including beetle, weevils and moths. In order to increase food security in Nigeria, government had established various agricultural research institutes. Institute for agricultural Research was established in 1924 to take care of genetic improvement and development of production and utilization technologies for sorghum, cowpea, cotton, groundnut, and sunflower and the improvement of farm based farming system in Nigeria (Adegbola *et al.,* 2013). However, most Nigerian farmers are illiterate and lack knowledge of modern storage techniques that could increase food security in the country; thereby there are huge losses of their harvested crops especially to insect pest.

Cowpea (*Vigna unguiculata* (L.) Walp) is one of the most important food legumes grown by many Nigerian farmers but infestation by *C. maculatus* (F.) has been a major problem to the storage of this weighty crop. The use of chemical pesticides has been the main approach to the control of this infamous insect pest. However, the pervasive use of such chemicals have noticeable hitches which have led researchers to concentrate more on plant kingdom for solutions leading to production of myriad of secondary compounds that could have toxic, antifeedant and growth reducing properties against insect (Zibaee, 2011; Akinneye and Ogungbite, 2013). Many botanical extracts had been found effective against C. maculatus, as an alternative, cheaper and ecofriendly means of controlling this pest (Ashamo and Odeyemi, 2001; Adedire *et al.*, 2011; Ashamo *et al.*, 2013).

In spite of the effectiveness of many botanical extracts, there are many associated problems that are thwarting their widespread use. For example Nicotine isolated from a number of Nicotiana spp is insecticidal but its use in insect control has dropped steadily because of the high cost of production, disagreeable odour, extreme mammalian toxicity, instability in the environment and limited insecticidal activity (Isman, 2008). Most of Nigerian farmers could not afford to buy many of the solvents used in the extraction of these botanical extracts and also consumers find it difficult to accept the effect pose by many of these botanical extracts. Such effects include colour change, change in taste of the commodity and unaccepted odour. Therefore, there is a need to look for alternative methods of application of botanical insecticides that could be produced at very low cost and also be acceptable to the consumers. Akinkurolere (2007) opined that many tropical plants such as dried pepper and its inert dusts have been used by local farmers for the protection of their grains because they believed that the powders could be easily washed away before cooking or consumption. For that reason, there is a need to search for new botanical powders that could be effective in protection of grains especially those that their extracts have been proved to be effective against insect pests. Moreso, the cost of production of plant powders is quiet low compared to their extracts.

*N. laevis* (Seem) is an important plant which its extracts have been proved to be effective against insect pest (Ashamo *et al.,* 2013). Therefore, this work investigated the powders of different parts of N. laevis against *C. maculatus.*

## MATERIALS & METHODS

### Insect culture

*Callosobruchus maculatus* was obtained from infested cowpea seeds from Food Storage Research Laboratory, Federal University of Technology, Akure, Nigeria. They were subsequently reared in 2-litre plastic containers in the laboratory on cleaned cowpea obtained from the Agricultural Development Programme (ADP), Akure at 28 ± 2°C and relative humidity of 75 ± 5%. Devoured and infested grains were replaced with fresh, clean and uninfested grains at appropriate times.

### Collection of Plant and Cowpea Seeds

Different parts of *N. laevis* were collected from Oke-Odo Aratunsin area of Akure, Ondo State, Nigeria. Collected plant was taken to Natural History Museum Obafemi Awolowo University, Ile-Ife for identification. The Ife Brown variety of cowpea used for the experiment was obtained from the Agricultural Development Project (ADP), Akure, Nigeria. The seeds were cleaned of foreign matter and disinfested by keeping in freezer at -5 oC for 7 days. They were then air-dried to attain a moisture content of about 12%.

### Preparation of plant powder

The wood ash was collected from burnt *N. laevis* stem wood and was sieved into fine ash before application. The ash was kept inside a covered container for subsequent use (Mesele et al., 2010). The plant parts (leaf, stem bark and root bark) used were collected fresh and sun dried. The plant parts were ground into fine powder using electric blender and the powders were further sieved to pass through 1mm2 perforations before being stored in separate plastic containers with tight lids for subsequent use (Ashamo, 2007; Asawalam et al., 2007).

### Experimental procedure

Twenty grammes of the cowpea seeds were weighed into 250ml plastic containers. Plant powders weighing 0.0g (control), 0.1g, 0.2g, 0.3g, 0.4g and 0.5g was weighed and thoroughly mixed with the cowpea seeds inside the plastic containers using glass rod. The experiment was set up in a complete randomized design and each treatment was replicated five times. The procedure was also done for wood ash of the plant. The treated cowpea at different concentration was left for one month, two months and three months. Five pairs of C. maculatus were introduced into those treated cowpea seeds immediately, then after one month, two months and three months of storage. Beetle mortality was assessed at 96 hours after introduction. Dead and live insects were removed and oviposition was noted. Also, percentage adult emergence, percentage weight loss and percentage damage seeds were calculated after 42days using the formulas below:

$$\%\text{damage seed} = \frac{\text{number of holed seed}}{\text{total number of seeds}} \text{x} \frac{100}{1}$$

$$\%\text{weight loss} = \frac{\text{initial weight} - \text{final weight}}{\text{initial weight}} \text{x} \frac{100}{1}$$

$$\%\text{Adult emergence} = \frac{\text{number of adult emerged}}{\text{total number of egg laid}} \text{x} \frac{100}{1}$$

### Statistical analysis

Data obtained were subjected to analysis of variance (ANOVA) and where significant differences existed, treatment means were compared at 0.05 significant levels using the New Duncan's Multiple Range Test (Zar, 1984).

## RESULTS

### Effect of *N. laevis* powders on mortality of adult *C. maculatus*

The effect of wood ash, leaf, stem bark and root bark powder of *N. laevis* on mortality of adult *C. maculatus* at different concentrations and periods for the first, second and third month of observation are presented in Table 1. The percentage beetle mortality varied with the period of exposure, type of plant part powder used and the concentration of the powders. There were significant ($P < 0.05$) differences in the mortality recorded by the powders. The effect of the powders on adult mortality of this beetle at all levels of concentration decreased from one to three months of observation. Moreover, it should be noted that at all levels of concentration the effect of these powders was significantly ($P < 0.05$) different from the control. At higher concentrations (0.4 and 0.5g/20g of cowpea seeds), all the powders of N. laevis achieved 100% beetle mortality within 96h of application for the three months of observation. However, the wood ash powder of *N. laevis* exhibited the greatest insecticidal activity and was more persistent than others. Results showed that the powders were still effective after three months of storage.

### Effect of plant powders of N. laevis on oviposition and adult emergence of *C. maculatus*.

All the powders significantly reduced the number of eggs laid by *C. maculatus*. However, the effect of these powders was not significantly ($P > 0.05$) different from each other (Table 2). At all level of concentration, the effect of these powders was significantly ($P < 0.05$) different from the control. More eggs were laid in the control than in treated seeds. An average of 35.80 eggs were laid in the control after 96hrs of treatment while only 9.33 eggs were laid in those treated with wood ash at 0.4 and 0.5g/20g of cowpea. Fewer eggs were laid at higher concentrations. Moreover, the number of eggs laid by the beetles slightly increased from the first month to the third month. The effect of leaf and stem bark powder *N. laevis* on oviposition of was not significantly different from the control at the third month of observation. Table 3 shows the effect of the leaf, stem bark, root bark and wood ash powder on adult emergence at different concentrations for the three months of storage. At all levels of concentration the powders reduced the number of adults that emerged. The effect of the powders was significantly ($P < 0.05$) different from the control. More adults emerged in the control than in treated samples. However, adult emergence was more at lower concentrations and also increased over the three months of storage. On the whole,

**Table 1:** Mortality (%) of adult C. maculatus on cowpea seeds treated with powder of N. laevis at 96 hours for three months. (% mean mortality ± S.E).

| Concentrations(g) | Treatments | Months | | | |
|---|---|---|---|---|---|
| | | 0 (initial) | 1 | 2 | 3 |
| 0.1 | Leaf | 80.00±0.58$^{b}$ | 77.00 ± 0.24$^{b}$ | 60.67± 0.33$^{b}$ | 60.00±0.58$^{cb}$ |
| | Stem | 77.00± 0.24$^{b}$ | 77.00 ± 0.40$^{b}$ | 63.37± 0.33$^{b}$ | 56.67± 0.33$^{b}$ |
| | Root | 86.70 ± 0.88$^{c}$ | 77.00 ± 0.40$^{b}$ | 73.33± 0.33$^{c}$ | 73.33± 0.33$^{d}$ |
| | Ash | 96.00±0.20$^{de}$ | 96.00±0.20$^{cd}$ | 86.67± 0.33$^{d}$ | 83.33± 0.33$^{e}$ |
| 0.2 | Leaf | 90.00± 0.32$^{d}$ | 90.00 ± 0.32$^{d}$ | 76.70± 0.33$^{c}$ | 73.33± 0.67$^{d}$ |
| | Stem | 92.00± 0.88$^{d}$ | 91.00 ± 0.40$^{d}$ | 80.00±0.58$^{cd}$ | 73.33± 0.33$^{d}$ |
| | Root | 93.00± 0.40$^{d}$ | 92.00 ± 1.29$^{d}$ | 86.70±0.33$^{d}$ | 76.67± 0.33$^{d}$ |
| | Ash | 100.00±0.00$^{e}$ | 100.00±0.00$^{d}$ | 93.30± 0.33$^{e}$ | 86.67± 0.33$^{e}$ |
| 0.3 | Leaf | 100.00±0.00$^{e}$ | 100.00±0.00$^{d}$ | 83.30± 0.88$^{d}$ | 83.33± 0.33$^{e}$ |
| | Stem | 100.00±0.00$^{e}$ | 99.00 ± 0.20$^{d}$ | 86.70± 0.88$^{d}$ | 80.00±0.00$^{de}$ |
| | Root | 100.00±0.00$^{e}$ | 100.00±0.00$^{d}$ | 90.00±0.58$^{de}$ | 86.67±0.33$^{d}$ |
| | Ash | 100.00±0.00$^{e}$ | 100.00±0.00$^{d}$ | 100.00±0.00$^{f}$ | 93.33±0.33$^{de}$ |
| 0.4 | Leaf | 100.00±0.00$^{e}$ | 100.00±0.00$^{d}$ | 100.00±0.00$^{f}$ | 100.00±0.00$^{f}$ |
| | Stem | 100.00±0.00$^{e}$ | 100.00±0.00$^{d}$ | 100.00±0.75$^{f}$ | 100.00±0.75$^{f}$ |
| | Root | 100.00±0.00$^{e}$ | 100.00±0.00$^{d}$ | 100.00±0.00$^{f}$ | 100.00±0.00$^{f}$ |
| | Ash | 100.00±0.00$^{e}$ | 100.00±0.00$^{d}$ | 100.00±0.00$^{f}$ | 100.00±0.00$^{f}$ |
| 0.5 | Leaf | 100.00±0.00$^{e}$ | 100.00±0.00$^{d}$ | 100.00±0.00$^{f}$ | 100.00±0.00$^{f}$ |
| | Stem | 100.00±0.00$^{e}$ | 100.00±0.00$^{d}$ | 100.00±0.75$^{f}$ | 100.00±0.75$^{f}$ |
| | Root | 100.00±0.00$^{e}$ | 100.00±0.00$^{d}$ | 100.00±0.00$^{f}$ | 100.00±0.00$^{f}$ |
| | Ash | 100.00±0.00$^{e}$ | 100.00±0.00$^{d}$ | 100.00±0.00$^{f}$ | 100.00±0.00$^{f}$ |
| Control | | 0.00 ± 0.00$^{a}$ | 6.70 ± 0.33$^{a}$ | 6.70 ± 0.33$^{a}$ | 6.70 ± 0.33$^{a}$ |

Each value is the mean ± standard error of 5 replicates. Mean followed by the same letters in the same column are not significantly (P > 0.05) different from each other using New Duncan's Multiple Range Test.

**Table 2:** Oviposition of adult C. maculatus of cowpea seeds treated with powders of N. laevis for three months.

| Concentrations(g) | Treatments | Months | | | |
|---|---|---|---|---|---|
| | | 0 (initial) | 1 | 2 | 3 |
| 0.1 | Leaf | 15.33±0.85[b] | 15.33±0.85[b] | 16.00±0.00[b] | 20.33±0.33[c] |
| | Stem | 14.60±0.58[b] | 16.00±0.58[b] | 17.00±0.58[c] | 20.00±0.58[c] |
| | Root | 14.60±0.88[b] | 14.67±0.88[b] | 15.00±0.58[b] | 19.67±0.33[c] |
| | Ash | 12.33±0.88[a] | 14.40± 0.40[b] | 14.67± 0.33[b] | 18.67±0.33[bc] |
| 0.2 | Leaf | 14.30±0.68[a] | 15.00±0.68[b] | 14.67±0.33[b] | 20.00±0.88[c] |
| | Stem | 13.40±0.93[a] | 15.33±0.93[b] | 16.00±0.00[b] | 19.67±0.68[c] |
| | Root | 12.22±0.40[a] | 14.60±0.68[b] | 14.33±0.33[b] | 16.00±0.58[b] |
| | Ash | 11.67±0.66[a] | 13.80±0.66[a] | 14.00±0.58[b] | 16.33±0.33[b] |
| 0.3 | Leaf | 13.40±0.51[a] | 14.40±0.58[b] | 14.33±0.33[b] | 18.00±0.58[bc] |
| | Stem | 14.20±0.37[a] | 14.33±0.67[a] | 11.67±0.33[a] | 19.33±0.33[c] |
| | Root | 11.33±0.88[a] | 14.40±0.04[a] | 11.33±0.88[a] | 14.67±0.88[b] |
| | Ash | 9.67±0.33[a] | 12.60±0.69[a] | 11.67± 0.33[a] | 14.00±0.58[b] |
| 0.4 | Leaf | 11.67±0.88[a] | 13.00±0.71[a] | 13.00±0.58[b] | 14.33±0.67[b] |
| | Stem | 11.60±0.88[a] | 12.20±0.58[a] | 11.67±0.88[a] | 14.33±0.33[b] |
| | Root | 10.00±0.58[a] | 12.40±0.93[a] | 10.67±0.33[a] | 14.00±0.58[a] |
| | Ash | 9.33 ±0.33[a] | 13.20±0.58[a] | 11.00±0.58[ab] | 13.00±1.00[a] |
| 0.5 | Leaf | 10.60±0.40[a] | 10.60±0.40[a] | 11.67±0.88[a] | 13.00 ±0.58[a] |
| | Stem | 10.67±0.88[a] | 11.60±0.67[a] | 11.00±0.58[a] | 11.67 ±0.88[a] |
| | Root | 9.67 ±0.45[a] | 11.00±0.45[a] | 10.67 ± 0.33[a] | 11.67 ±0.33[a] |
| | Ash | 9.33±0.67[a] | 11.00±0.63[a] | 10.67 ± 0.67[a] | 11.67 ±0.88[a] |
| Control | | 35.80±1.15[c] | 20.33± 0.88[c] | 20.33± 0.88[d] | 20.33± 0.88[b] |

Each value is the mean of ± standard error of 5 replicates. Mean followed by the same letters within the same column are not significantly (P > 0.05) different from each other using New Duncan's Multiple Range Test.

wood ash was able to suppress adult emergence more than others.

**Seed damage and weight loss caused by C. maculatus infestation in cowpea treated with *N. laevis* powders after one month post treatment**

Tables 4, 5 and 6 shows the effect of *N. laevis* powders on ability of *C. maculatus* in causing seed damage and weight loss. At all levels of concentration the powder significantly reduced the damage caused by the beetle. However, none of the powders achieved 0% seed damage. Moreover, the effect of the powders in reducing damage of the seeds were not significantly (P>0.05) different from each other but was significantly (P < 0.05) different from the control. More cowpea seed damage and weight loss occurred in the control than in treated samples. For the three months of storage the seed damage and weight loss decreased with increase in concentration. The percentage weight loss was significantly (P< 0.05) different from the control. Moreover, none of the plant powder achieved 0% seed weight loss. The root powder had the highest effect of reducing seed damage and seed weight loss. However, its effect was not significantly different from that of other powders.

## DISCUSSIONS

The use of botanical insecticides to protect crops and stored products is as old as crop protection. Indeed, prior to the development and commercial success of synthetic insecticides beginning in the 1940s, botanical insecticides are major weapons in the farmer's arsenal against crop pests (Isman, 2008). The results obtained in this study showed that the powders of *N. laevis* were effective against *C. maculatus* producing high mortality, reducing oviposion and adult emergence as well as reducing cowpea seed damage and weight loss. At different concentrations, the powders of *N. laevis* (leaf, stem bark and root bark) achieved high beetle mortality. The wood ash achieved higher beetle mortality even at lower concentrations and performed better than others. The effect of the powder increased with increase in the powder concentration and period of exposure. The result obtained from the ash powder may be due to the fact that wood ash acted as a physical poison which usually affects the cuticle of the insects and cause death of the insect through desiccation (Tadesse and Basedow, 2005). These results were similar to findings of Rahman and Talukdar (2006) in which Bablash ash was more effective on *C. maculatus* than nishinda, eucalyptus and Bankhami leaf powder. The result agreed with the report of Singh (2011) in which mahogany wood ash was used to control Callosobruchus chinensis.

Moreover, research of Ashamo *et al.,* (2013) in which root oil extract was more effective than the extract of the ash disagree with these results. The high mortality rate of C. maculatus achieved by N. laevis powders may be associated with the inability of the beetle to feed on the cowpea that have been coated with these powders thereby leading to their starvation. The powders may have blocked the spiracle of the insects thereby causing suffocation. Moreover, the high mortality effect of the powder of this plant was similar to that of Anarcardium occidentalis powder on C. maculatus (Oparaeke and Bunmi, 2006; Adedire *et al.,* 2011). It was observed also that wood ash and plant parts of N. laevis were effective against the oviposition of *C. maculatus*. All the powders reduced oviposition of the beetle and their effect on the beetles was directly proportional to the increase in their dosages. This result agreed with previous work which stated that botanicals have effect on oviposition of insects and that reduction in insect oviposition increased with increase in dosage of treatments (Araye and Emana 2009; Orunoye and Okrikata, 2010). The adult emergence of the beetle was reduced by the powders. This result was in support of Wolfson et al. (1991), Tadesse and Basedow (2005) and Singh (2011) which suggested that wood ash reduced adult emergence of *C. maculatus*. The inability of this insect egg to develop into adult beetle may be due to the death of the insect larvae which was unable to fully cast off their old exoskeleton which typically remained linked to the posterior part of the abdomen (Oigiangbe et al., 2010). However, none of the powders was able to prevent the emergence of the adult beetle. This disagreed with the work of Ashamo et al. (2013) in oil extract of N. laevis was able to protect adult emergence of C. maculatus. These powders were able to reduce the seed damage and seed weight loss that may occur due to attack from *C. maculatus*. The ability of the wood ash to reduce seed damage and weight loss may be as a result of the inability of the larvae to feed on the treated cowpea (Rahman and Talukdar, 2006; Asawalam et al., 2007).

The reduction in seed damage and weight loss due to the treatment of leaf, stem bark and root bark of N. laevis may be due to the inability of the larva of C. maculatus to feed on the treated cowpea seeds. Ogunlana and Ogunlana (2008), Bafor and Sanni (2009) as well as Akerele et al. (2011) found different phytochemical compound in different parts of this plant. Many of these phytochemical compounds which include tannins, flavonoids, saponins, alkaloids, steroidal glycosides, terpenes and cardiac glycosides and had been reported to have antifeedant effect, growth effects and also possessed considerable toxicity toward insect (Yang *et al.,* 2006; Adeniyi et al., 2010; Kambou and Guisson 2011; Saiful *et al.* 2011). For example, alkaloid had been reported to have inhibitory effect on oviposition of insects (Yang et al., 2006). This result was in support of Oigiangbe et al. (2010) which stated that alkaloid found in A. boonei disrupted growth and reduced larva survival as well as disruption of life cycle of insects (Yang *et al*., 2006). However, the ability of this powder to protect stored cowpea decreased with increase in period of post treatment. The powders of the plant lost their potency gradually over the period of three months of storage of cowpea. It was noted that the ash powder lost its potency faster than other powders while the root powder lost its potency slower than other powders. The gradual decrease in the effectiveness of these powders may be due to the loss of their potency over time because botanical pesticides are short lived; therefore, there should be an increase in their concentration or frequency of application for them to maintain high effectiveness and to obtain a reasonable degree of plant protection (Oruonye and Okrikata, 2010). From the results obtained in this research, it can be concluded that the powders of this plant have good insecticidal activities against C. maculatus and could be encouraged among Nigerian poor resource farmers that could not afford synthetic chemical insecticides as well as the extracts of many effective botanicals. However, the effectiveness of these powders against *C. maculatus* was reduced gradually after a long period of exposure.

**Table 3:** Adult emergence (%) of *C. maculatus* of cowpea seeds treated with powders of *N. laevis* for three months.

| Concentrations(g) | Treatments | Months | | | |
|---|---|---|---|---|---|
| | | 0 (initial) | 1 | 2 | 3 |
| 0.1 | Leaf | 45.19±3.85[c] | 47.49±2.94[c] | 56.82±1.93[de] | 71.55± 1.46[b] |
| | Stem | 41.00±2.00[c] | 46.81±1.81[bc] | 58.33±2.08[de] | 72.07± 2.89[b] |
| | Root | 39.89±2.23[bc] | 41.99±1.76[b] | 53.19±1.81[d] | 60.05±6.90[ab] |
| | Ash | 41.71±2.08[c] | 49.13±3.41[c] | 54.17±5.51[d] | 54.17± 4.17[a] |
| 0.2 | Leaf | 43.00±1.11[c] | 46.62±0.26[bc] | 52.22± 4.01[d] | 63.41±3.91[b] |
| | Stem | 40.34±1.73[c] | 45.39±4.05[bc] | 56.76±4.29[d] | 65.86±5.31[b] |
| | Root | 38.65±0.73[b] | 40.26±2.23[b] | 46.67±5.30[b] | 46.94±4.82[a] |
| | Ash | 38.93±2.52[b] | 48.15±1.85[c] | 47.45±3.09[bc] | 48.89±4.27[a] |
| 0.3 | Leaf | 40.44±1.29[c] | 41.83±1.31[b] | 47.18±3.02[bc] | 57.64±4.86[a] |
| | Stem | 38.17±3.00[b] | 43.19±2.45[b] | 45.94±2.41[b] | 58.89±4.84[a] |
| | Root | 35.75±1.60[a] | 37.95±1.07[ab] | 41.30±2.12[b] | 45.87±4.14[a] |
| | Ash | 36.30±1.34[ab] | 39.34±1.57[ab] | 46.97±1.52[b] | 45.04±3.42[a] |
| 0.4 | Leaf | 38.33±2.19[b] | 39.83±3.70[ab] | 41.18±3.02[b] | 46.50±0.17[b] |
| | Stem | 34.62±1.72[a] | 40.84±2.86[b] | 45.56±2.94[b] | 48.73±3.09[b] |
| | Root | 31.79±2.18[a] | 36.08±1.52[a] | 35.45±2.92[a] | 38.06±1.25[a] |
| | Ash | 33.74±2.85[a] | 39.25±3.23[ab] | 42.12±4.08[b] | 46.11±2.42[b] |
| 0.5 | Leaf | 35.61±2.44[a] | 38.27±1.05[ab] | 40.83±2.86[b] | 46.12±3.88[b] |
| | Stem | 36.29±1.12[a] | 40.52±1.96[b] | 45.15±2.89[b] | 45.94±2.41[b] |
| | Root | 34.12±2.75[a] | 35.45±2.92[a] | 34.24±2.12[a] | 35.83±1,48[a] |
| | Ash | 31.28±2.75[a] | 31.28±2.75[a] | 42.37±1.61[b] | 45.89±2.41[b] |
| Control | | 88.05±1.70[d] | 89.89± 3.25[d] | 89.89± 3.25[f] | 89.89± 3.25[c] |

Each value is the mean of ± standard error of 5 replicates. Mean followed by the same letters within the same column are not significantly (P > 0.05) different from each other using New Duncan's Multiple Range Test.
xxIt should be noted that each concentration was compared with the control.

**Table 4:** Seed damage (%) and weight loss (%) caused by *C. maculatus* infestation on cowpea treated with *N. laevis* powders one month post treatment.

| Treatments | 0.1g | 0.2g | 0.3g | 0.4g | 0.5g |
|---|---|---|---|---|---|
| Leaf | 7.17 ± 0.35[a] | 6.32± 0.33[a] | 6.61± 0.37[a] | 5.15± 0.29[a] | 5.09± 0.33[a] |
| | (1.05 ± 0.87[a]) | (1.02± 0.16[a]) | (0.95± 0.07[a]) | (0.72± 0.09[a]) | (0.68± 0.06[a]) |
| Stem | 8.73 ± 0.40[a] | 7.43± 1.15[a] | 6.27± 0.32[a] | 6.22± 0.38[a] | 5.35± 0.30[a] |
| | (1.57 ± 0.87[a]) | (1.00± 0.18[a]) | (0.92± 0.07[a]) | (0.88± 0.09[a]) | (0.80± 0.03[a]) |
| Root | 7.02 ± 0.63[a] | 6.84± 0.48[a] | 6.28± 0.43[a] | 4.66± 0.39[a] | 3.53± 0.04[a] |
| | (1.00 ± 0.04[a]) | (0.93± 0.09[a]) | (0.77± 0.11[a]) | (0.72± 0.02[a]) | (0.67± 0.04[a]) |
| Ash | 6.64 ± 0.39[a] | 5.80 ± 0.33[a] | 5.15± 0.36[a] | 4.27± 0.39[a] | 3.73 ± 0.44[a] |
| | (0.98 ± 0.11[a]) | (0.92± 0.02[a]) | (0.77± 0.04[a]) | (0.70± 0.03[a]) | (0.60± 0.50[a]) |
| Control | 20.77± 2.26[b] | 20.77± 2.26[b] | 20.77± 2.26[b] | 20.77± 2.26[b] | 20.77± 2.26[b] |
| | (10.30±1.00[b]) | (10.30±1.00[b]) | (10.30±1.00[b]) | (10.30±1.00[b]) | (10.30±1.00[b]) |

Each value is the mean of ± standard error of 5 replicates. Mean followed by the same letters within the same column are not significantly (P > 0.05) different from each other using New Duncan's Multiple Range Test.

**Table 5:** Seed damage and weight loss caused by *C. maculatus* infestation on cowpea treated with *N. laevis* powders two months post treatment.

| Treatments | 0.1g | 0.2g | 0.3g | 0.4g | 0.5g |
|---|---|---|---|---|---|
| Leaf | 9.81 ± 0.80[a] | 8.93 ±1.08[a] | 7.86± 0.84[a] | 6.24± 0.33[a] | 5.90± 0.06[a] |
| | (1.53 ± 0.09[a]) | (1.38± 0.16[a]) | (1.18± 0.13[a]) | (0.87± 0.09[a]) | (0.83± 0.11[a]) |
| Stem | 10.57±0.53[a] | 10.20±0.45[a] | 8.20± 0.66[a] | 7.40± 0.79[a] | 6.20± 0.35[a] |
| | (1.57 ± 0.12[a]) | (1.67± 0.04[a]) | (1.10± 0.09[a]) | (1.00± 0.09[a]) | (0.85± 0.03[a]) |
| Root | 9.02 ± 0.36[a] | 8.07 ± 0.80[a] | 7.10± 0.74[a] | 5.84± 0.06[a] | 5.10± 0.39[a] |
| | (1.42 ± 0.12[a]) | (1.18± 0.09[a]) | (0.90± 0.06[a]) | (0.75± 0.03[a]) | (0.68± 0.04[a]) |
| Ash | 9.03 ± 0.84[a] | 7.83 ± 0.85[a] | 6.93± 0.98[a] | 5.09± 0.43[a] | 5.06± 0.35[a] |
| | (1.45 ± 0.09[a]) | (1.20± 0.10[a]) | (0.85± 0.06[a]) | (0.78± 0.04[a]) | (0.68± 0.02[a]) |
| Control | 20.77± 2.26[b] | 20.77± 2.26[b] | 20.77± 2.26[b] | 20.77± 2.26[b] | 20.77± 2.26[b] |
| | (10.30±1.00[b]) | (10.30±1.00[b]) | (10.30±1.00[b]) | (10.30±1.00[b]) | (10.30±1.00[b]) |

Each value is the mean of ± standard error of 5 replicates. Mean followed by the same letters within the same column are not significantly (P > 0.05) different from each other using New Duncan's Multiple Range Test.
[xx] Values in parenthesis shows weight loss of cowpea seeds.

**Table 6:** Seed damage and weight loss caused by *C. maculatus* infestation on cowpea treated with *N. laevis* powders after three months post treatment.

| Treatments | 0.1g | 0.2g | 0.3g | 0.4g | 0.5g |
|---|---|---|---|---|---|
| Leaf | 14.55±1.57[ab] | 10.61±1.09[ab] | 9.88 ± 0.78[a] | 7.45± 0.44[a] | 6.59± 0.06[a] |
| | (2.15 ± 0.20[a]) | (1.67± 0.14[a]) | (1.58± 0.09[a]) | (1.20± 0.06[a]) | (0.97± 0.09[a]) |
| Stem | 15.24±0.68[a] | 12.77±1.26[b] | 10.53±0.57[a] | 8.23± 0.63[a] | 7.07± 0.35[a] |
| | (2.12 ± 0.18[a]) | (1.93± 0.19[a]) | (1.73± 0.19[a]) | (1.32± 0.08[a]) | (1.02± 0.07[a]) |
| Root | 11.69±1.44[ab] | 9.30 ± 0.63[ab] | 7.88 ± 0.49[a] | 6.25± 0.49[a] | 5.52± 0.39[a] |
| | (1.80 ± 0.20[a]) | (1.33± 0.09[a]) | (1.30± 0.08[a]) | (1.02± 0.09[a]) | (0.75± 0.03[a]) |
| Ash | 9.71 ± 0.95[a] | 8.27± 0.74[a] | 7.16 ± 0.67[a] | 6.77± 0.37[a] | 6.28± 0.35[a] |
| | (1.60 ± 0.08[a]) | (1.48± 0.06[a]) | (1.23± 0.04[a]) | (1.07± 0.09[a]) | (0.78± 0.04[a]) |
| Control | 20.77±2.26[c] | 20.77± 2.26[c] | 20.77±2.26[b] | 20.77± 2.26[b] | 20.77± 2.26[b] |
| | (10.30±1.00[b]) | (10.30±1.00[b]) | (10.30±1.00[b]) | (10.30±1.00[b]) | (10.30±1.00[b]) |

Each value is the mean of ± standard error of 5 replicates. Mean followed by the same letters within the same column are not significantly (P > 0.05) different from each other using New Duncan's Multiple Range Test.
[xx] Values in parenthesis shows weight loss of cowpea seeds.

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