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# POTENTIALS OF TOBACCO (*Nicotiana tabacum L.*) LEAVES POWDER FOR THE CONTROL OF COWPEA BRUCHID (*Callosobruchus maculatus L. Walp.*) ON STORED COWPEA (*Vigna unguiculata L. (Walp.*) SEEDS

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## SUMMARY

**A laboratory study was conducted under the ambient temperatures of between 30-33°C and 60-65% relative humidity to evaluate the efficacy of tobacco leaf powder for the control of *C. maculatus* on three varieties of stored cowpea namely "Kanannado", "Bosop", and "Danlergo". The study was set-up in a Completely Randomized Design (CRD) with three replicates. The treatments consisted of four levels of tobacco leaf powder $T_1$ (2g). $T_2$ (4g) and $T_3$ (6g), and a control ($T_0$). Fifty (50) g of dried cowpea seeds were used in each treatment. Data collected included adult mortality, juvenile mortality and average number of exit holes. All data collected were subjected to Analysis of Variance (ANOVA), and means separated using the Duncan Multiple Range Test (DMRT). The results obtained from the study showed significant variations in the efficacy of the different levels of tobacco leaf powders tested. It was observed that cowpea treated with 6g of tobacco leaf powder were the best as compared to other treatment levels. Parameters used to determine efficacy of tobacco leaf powder in controlling cowpea bruchid include insect adult and juvenile mortalities and number of exit holes or average number of holes (ANH). The results revealed that tobacco leaf powder protected stored cowpea seeds against *C. maculatus infestation* during the period (16 days after treating cowpea seeds with tobacco leaves powder) of the experiment.**

**Keywords**: Tobacco leaves powder, cowpea bruchids, stored cowpea

**Cowpea** (*Vigna unguiculata* (L.) Walp.), subfamily Papilionoideae, family Fabaceae (formerly Leguminosae) (44), is a dicotyledonous plant regarded as the most important food legume in tropical and sub-tropical countries of the world (9). It is a drought-tolerant and short-warm weather crop, well adapted to drier regions where other food legumes do not perform well (48). It requires an annual rainfall of about 750 -1100mm (51).

The estimated worldwide area under cowpea production is more than 12 million hectares, of which West Africa alone accounts for about 9.3 million hectares, with annual production of 2.9 – 3.3 million tonnes (50, 23, 1). In Africa, the main cowpea-producing countries are Nigeria, Niger, Burkina Faso, Ghana, Kenya, Uganda, Malawi and Senegal (47). Fatokun *et al*. (2009) reported that production of cowpea has steadily risen from 33kg/ha in the 1900s to 470kg/ha in 2006 in West Africa and to 670kg/ha in Nigeria. Africa leads the world, and it accounts for about 70% of the total production of cowpea, and

Nigeria accounts for 58% of worldwide production (22) hence being both the largest producer and consumer of cowpea worldwide (34).

Cowpea cultivation is mostly done by peasants in developing countries (46, 33), being a source of the desperately needed protein lacking in their diets (6). Cowpea also contains several other minerals that the body requires to remain in a good state of health (56) especially for poor people that cannot afford the more expensive animal-based proteins (18). Studies reveal that a quarter of a cowpea grain is made up of protein, 50-67% carbohydrate and 1.9% fat, making it one of the most nutritious crops cultivated in the tropics (12).

Despite the nutritional and economic values of cowpea such as compensating for the protein shortage in households' diets, cowpea production and storage are adversely affected by insect pests' infestations leading to significant yield losses (46, 7). Bean weevil, *Callosobruchus maculatus* is the most important storage insect pest attacking cowpea (2). *C. maculatus* can damage about 50% of the seeds after four months of storage (16), making it the most important postharvest insect pest of cowpea in the tropics (15). It causes significant losses both in the quality and in quantity of cowpea manifested by seed perforations, and reduction in weight, market value, and germination ability of seeds (45). Lale and Vidal (37) reported C. *maculatus* to be more destructive on account of its shorter life cycle and higher intrinsic fecundity, especially when compared to its closely related *C. subinnotatus*, the major insect pest of stored Bambara groundnut. The presence of emergence holes on stored pulses due to the destructive activity of this insect pest has far-reaching effects, such as reducing the value of the pulse leading, to total loss (24). In addition, consumer preference studies show that cowpea buyers have zero tolerance for insect-damaged cowpea grains and that those with bruchid-made exit holes reduce the quality and price of cowpea grains (25)

Female *C. maculatus* lay white eggs on stored cowpea seeds or pods, depending on the form of storage (10, 3, 20). When eggs hatch and larvae emerge, they penetrate the seeds and destroy cowpea seeds (25). Cowpea seed infestation by both larvae and adults causes very severe damage sometimes leading to total loss of cowpea seeds (49).

*C. maculatus damage on cowpea* are most of the time mitigated by employing the use of chemical insecticides, which are most often harmful to the environment, non-target organisms and man (11, 29). Furthermore, the challenge of insects developing resistance against insecticides has been reported as one of the shortcomings of indiscriminate use of insecticide use (52). However, recent studies have shown that synthetic insecticides were found to penetrate grains and may be toxic as well as persistent in the environment as residue (52). In addition, Ekeh *et al*. (20) reported an instance of residues of methyl bromide, a fumigant found on stored food commodities, persisting, resulting in cancers in consumers. Therefore, it becomes imperative to develop an alternative control strategy that is safe and environmentally friendly such as use of botanicals, to protect agricultural produce against insect pest infestation.

The use of botanicals in the control of insect pests has been reported by Lale (38), Nwaubani and Fasoranti (42), and Buba and Zakka (14). Botanicals can be applied as vegetable oils, spices, plant powders and extracts of plant parts (42), thereby reducing reliance on chemical pesticides (30). The advantages of botanicals over

synthetic pesticides include being easily degradable, non-persistence and safe to the environment, non-toxicity to man, animals, and the environment, being difficult to develop resistance against, and ease of preparation even by village level technology (38).

Some of the common plant-based non-synthetic pesticides used in the control of insect pests include tobacco (*Nicotiana tabacum*) (25, 4), ginger (*Zingiber officinale*) (4, 57), pyrethrum (17) and neem (*Azadirachta indica*) (13). Others include cocoa pod ash, plantain skin ash, palm oil (19) and chilli pepper (4).

An outstanding botanical used in insect pest control is tobacco, which contains many phytochemicals, with nicotine being the principal component as well as the most toxic to insect pests (32, 31). Tobacco is a quick-acting insecticide, which acts as a stomach poison and is an important chemical utilized by the tobacco plant as part of its defence mechanism from insect attack (21). According to Muck (41), apart from its insecticidal properties, tobacco has other uses.

Recently, farmers are becoming increasingly aware of the environmental hazards caused by over-dependence and overuse of chemical pesticides. This is in addition to the adverse effects of these chemicals on beneficial and non-target organisms as well as their high cost. It is in view of finding an alternative to synthetic chemical pesticides that would be affordable, readily available, as well as safe for the environment, non-target organisms and humans that this research was conducted. This research aimed to evaluate the efficacy of tobacco leaves powder for the control of cowpea bruchid, *C. maculatus,* in stored cowpea.

## MATERIALS AND METHOD

**Experimental Site**

The experiment was conducted in the laboratory of the Department of Agronomy, Faculty of Agriculture, Federal University of Kashere, Gombe state. The experimental site is located in the Sudan savanna ecological zone of Nigeria within latitude 09°69′N and 11°56′E of the equator, and an altitude of 431m above sea level (26)

**Source of cowpea seeds**

Three varieties of stored cowpea, "*Kanannado", "Bosop",* and "*Danlergo"* were sourced from the open market in Kashere. The seeds were sorted into infested and uninfested. The cowpea seeds already infested with *C. maculatus* eggs were set aside while the undamaged were used to set up the experiment. The undamaged cowpea seeds were put in plastic bags, labelled and put in a deep freezer at -4°C for 72 hours. This is to halt the metabolic activities in all stages of development of *C. maculatus* before use in the experiment. Thereafter, they were sundried until they became brittle (35, 8).

**Preparation of tobacco leaves powder**

Tobacco leaves were sourced from Gwaram village near Kashere town, Akko Local Government Area. These were washed, and air-dried under shade, away from direct sunlight (to preserve their active constituents). The leaf samples were ground into a fine powder using an electric blender and sieved. The powders were kept in airtight containers until needed.

**Preparation of initial *C. maculatus* culture of unknown age**

Samples of infested cowpea seeds from the three cowpea varieties mixed in equal ratios of 20g each to make a total of 60g were put in a 1-litre glass container. The glass container was covered with a piece of muslin cloth held in place with a rubber

band to ensure adequate ventilation for the insects and prevent the insects from escaping. This was replicated five times and was used to culture the initial population of *C. maculatus* used for the study.

**Culturing *C. maculatus* of known age ($F_1$ Generation)**

Sixty grams (60 g) each of the three disinfested cowpea varieties were mixed with Bambara nuts and put in 5 different containers each measuring 1 litre to remove any bias on *C. maculatus* growth arising from source of food. Fifty adults of *C. maculatus* obtained from the initial insect culture were transferred to the new containers. The containers were left undisturbed for 6 days for insects to mate and lay eggs until pristine *C. maculatus* adults emerged.

Fifty grams each of disinfested cowpea varieties were put in well-labelled, muslin-cloth-covered plastic containers. Forty pristine adult *C. maculatus* of the same age were picked from the second insect culture and put in each container. Each of the containers was replicated 3 times.

**Application of tobacco leaf powder to cowpea varieties**

Tobacco leaf powder of 2g, 4g, and 6g were applied to each cowpea varieties. There was also a control treatment for each of the cowpea varieties with 0g of tobacco leaf powder. These four treatment levels were applied to the labelled containers containing cowpea and pristine adult *C. maculatus*. Containers were left open without their covers but covered with muslin cloths and secured with rubber bands. Each of the treatments was replicated three times. Treatments were arranged in a Completely Randomized Design (CRD) on a workbench in the laboratory.

**Data Collection**

Data collected include adult mortality (AM), juvenile mortality (JM), number of exit holes (NEH) on cowpea seed (severity of damage on seeds), and adult emergence (AE).

**Procedure for Taking Data from the Treatments**

Adult mortality was determined by removing and counting daily mortalities of adult *C. maculatus* for 16 days after treatment with tobacco leaves powder. Determining juvenile mortalities followed the same procedure for counting dead juveniles of *C. maculatus* and discarding them. To determine mean number of exit holes, 20 cowpea seeds were selected at random from each container and the mean number of exit holes calculated by dividing the number of holes by the total number of cowpea seeds (20).

**Data Analysis**

The data collected on various parameters were analyzed statistically using Analysis of Variance (ANOVA) by deploying SAS statistical package. Means were compared by Duncan Multiple Range Test (DMRT).

## RESULTS

**Adult mortality of *C. maculatus* treated with four levels of tobacco leaf powde**r

The result of the *C. maculatus* adult mortality on cowpea treated with tobacco leaf powder is presented in Table 1. The result showed that there was no significant difference ($p>0.05$) between the treatment levels on the day 2 to day 8 of the experiment. However, there were significant differences between the treatment levels on day 10 of storage. The result also indicated that there was an increase in mortality rate as the storage time increased. The highest mortality was recorded on day 8 of the experiment. The highest mortality was recorded on cowpea that was treated with 6g tobacco leaf powder.

**Table 1: Adult mortality *C. maculatus* on cowpea treated with four levels of tobacco leaf powder**

| | Days After Treatment | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Treatment level (g)** | **2** | **4** | **6** | **8** | **10** | **12** | **14** | **16** |
| **6** | 3.44[a] | 5.77[a] | 7.66[a] | 11.77[a] | 9.33[a] | 7.00[a] | 3.89[a] | 2.22[a] |
| **4** | 2.11[b] | 4.66[b] | 6.44[b] | 9.77[b] | 9.11[a] | 5.00[b] | 1.66[b] | 0.66[b] |
| **2** | 0.88[c] | 1.66[c] | 4.22[c] | 8.44[b] | 8.77[a] | 1.77[c] | 0.55[c] | 0.33[cb] |
| **0** | 0.00[d] | 0.00[d] | 0.00[d] | 0.00[c] | 0.00[b] | 0.11[d] | 0.22[c] | 0.11[c] |

**Means in the same column with the same letters are not significantly different**

## Juvenile mortality of *C. maculatus* on cowpea treated with four levels of tobacco leaf powder

The result of the juvenile mortality of *C. maculatus* is presented in Table 2. The result showed a significant increase in mortality on day 8 of the experiment with an increase in storage time. The highest juvenile mortalities were observed on day 12 of storage. The lowest juvenile mortalities of *C. maculatus* were recorded on control. Consequently, the highest juvenile *C. maculatus* mortalities were recorded in cowpea treated with 6g of tobacco leaves powder in all the storage days.

**Table 2: Juvenile mortality of *C. maculatus* on cowpea treated with four levels of tobacco leaf powder**

| | Days After Treatment | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Treatment level (g)** | **2** | **4** | **6** | **8** | **10** | **12** | **14** | **16** |
| **6** | 1.88[a] | 3.00[a] | 4.33[a] | 6.00[a] | 7.22[a] | 10.00[a] | 8.11[a] | 3.55[a] |
| **4** | 1.00[b] | 1.77[b] | 2.55[b] | 3.66[b] | 5.33[b] | 6.11[b] | 5.88[b] | 3.44[a] |
| **2** | 0.77[b] | 1.11[c] | 1.55[c] | 2.11[c] | 3.66[c] | 4.22[c] | 4.66[b] | 3.11[a] |
| **0** | 0.00[c] | 0.00[d] | 0.00[d] | 0.00[d] | 0.00[d] | 0.11[d] | 0.22[c] | 0.00[b] |

Means in the same column with the same letter are not significantly different ($p>0.05$)

## Adult mortality of *C. maculatus* on three varieties of cowpea treated with four levels of tobacco leaf powder

Adult mortalities on tobacco leaf powder and cowpea treatments are presented in Table 3. The result shows no significant difference ($p>0.05$) in adult mortalities between the treatments form day 2 to 10 after storage. However, there was a significant difference ($p\leq0.05$) in adult *C. maculatus* mortalities between the treatments from day 10 to the sixteenth day of the experiment in all the treatment combinations. *C. maculatus* adult mortality rate also increases in each of the treatments from day 4 to the day 10. The lowest *C. maculatus* adult mortalities were recorded in control.

**Table 3: Adult mortality of *C. maculatus* on three cowpea varieties treated with four levels of tobacco leaf powder**

| | Days After Treatment | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Treatment** | **2** | **4** | **6** | **8** | **10** | **12** | **14** | **16** |
| KAN 0g | $0.00^{c}$ | $0.00^{e}$ | $0.00^{e}$ | $0.00^{e}$ | $0.00^{c}$ | $0.33^{cb}$ | $0.33^{d}$ | $0.00^{b}$ |
| KAN 2g | $1.00^{bc}$ | $3.33^{d}$ | $5.66^{bc}$ | $12.00^{ba}$ | $10.33^{a}$ | $3.33^{cb}$ | $1.33^{cd}$ | $1.33^{ba}$ |
| KAN 4g | $3.33^{ba}$ | $5.66^{bac}$ | $7.00^{ba}$ | $13.66^{a}$ | $7.00^{ba}$ | $3.00^{cb}$ | $0.66^{d}$ | $0.00^{b}$ |
| KAN 6g | $5.00^{a}$ | $7.33^{a}$ | $9.00^{a}$ | $14.33^{a}$ | $3.33^{bc}$ | $0.66^{cb}$ | $0.33^{d}$ | $0.00^{b}$ |
| BOS 0g | $0.00^{c}$ | $0.00^{e}$ | $0.00^{e}$ | $0.00^{e}$ | $0.00^{c}$ | $0.00^{c}$ | $0.33^{d}$ | $0.00^{b}$ |
| BOS 2g | $1.00^{bc}$ | $0.66^{e}$ | $3.33^{d}$ | $8.00^{bdc}$ | $9.66^{a}$ | $8.00^{a}$ | $4.00^{b}$ | $2.66^{a}$ |
| BOS 4g | $2.00^{bc}$ | $5.00^{bdc}$ | $6.66^{b}$ | $9.00^{bdc}$ | $11.00^{a}$ | $4.00^{b}$ | $1.00^{d}$ | $1.00^{b}$ |
| BOS 6g | $3.33^{ba}$ | $6.00^{ba}$ | $7.33^{ba}$ | $10.33^{bac}$ | $11.00^{a}$ | $2.00^{cb}$ | $0.00^{d}$ | $0.33^{b}$ |
| DAN 0g | $0.00^{c}$ | $0.00^{e}$ | $0.00^{e}$ | $0.00^{e}$ | $0.00^{c}$ | $0.00^{c}$ | $0.00^{d}$ | $0.33^{b}$ |
| DAN 2g | $0.66^{c}$ | $1.00^{e}$ | $3.66^{dc}$ | $5.33^{d}$ | $7.33^{ba}$ | $9.66^{a}$ | $6.33^{a}$ | $2.66^{a}$ |
| DAN 4g | $1.00^{bc}$ | $3.33^{d}$ | $5.66^{bc}$ | $6.66^{dc}$ | $10.00^{a}$ | $8.00^{a}$ | $3.33^{cb}$ | $1.00^{b}$ |
| DAN 6g | $2.00^{bc}$ | $4.00^{dc}$ | $6.66^{b}$ | $10.66^{bac}$ | $12.00^{a}$ | $2.66^{cb}$ | $1.33^{cd}$ | $0.66^{b}$ |

Means with same letters within a column are not significantly different ($p>0.05$)

Key: KAN.: kanannado, BOS.: Bosop, DAN.: Danlergo

The results of the tobacco powder treatment levels on the number of exit holes (ANH) on stored cowpea are presented in Fig. 1, where it shows a significant difference ($p \leq 0.05$) between the means of exit holes in control and the other cowpea varieties treated with tobacco leaf powder levels.

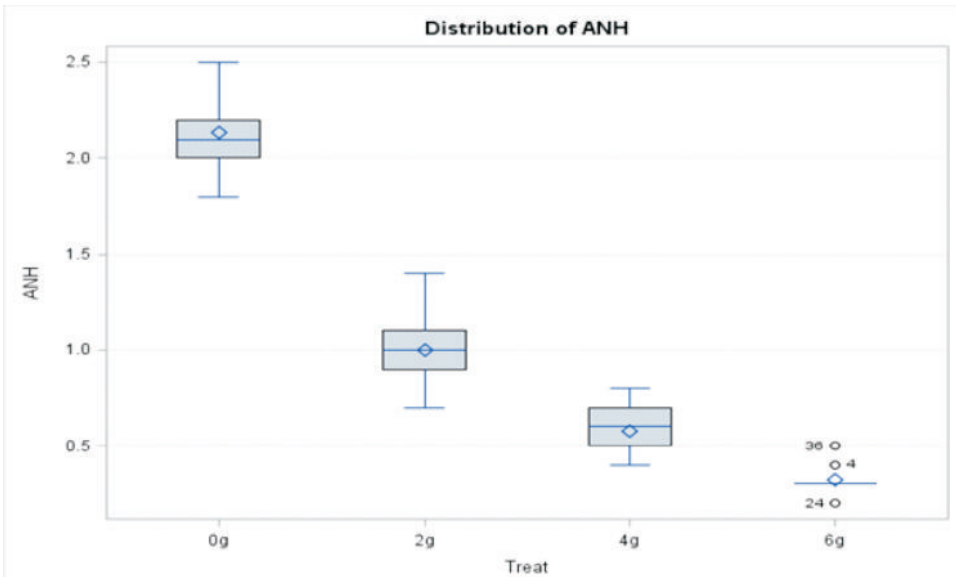


**Fig. 1:** Showing average number of exit holes made by *C. maculatus* on cowpea treated with three levels of tobacco leaf powder and control

Legend: 1. ANH – Average Number of Holes

2. Treat. – Treatments

Figure 2 shows interaction between cowpea varieties and tobacco treatment levels on average number of holes where all varieties without control gave significantly higher number of holes compared with those with other levels of tobacco treatment levels.

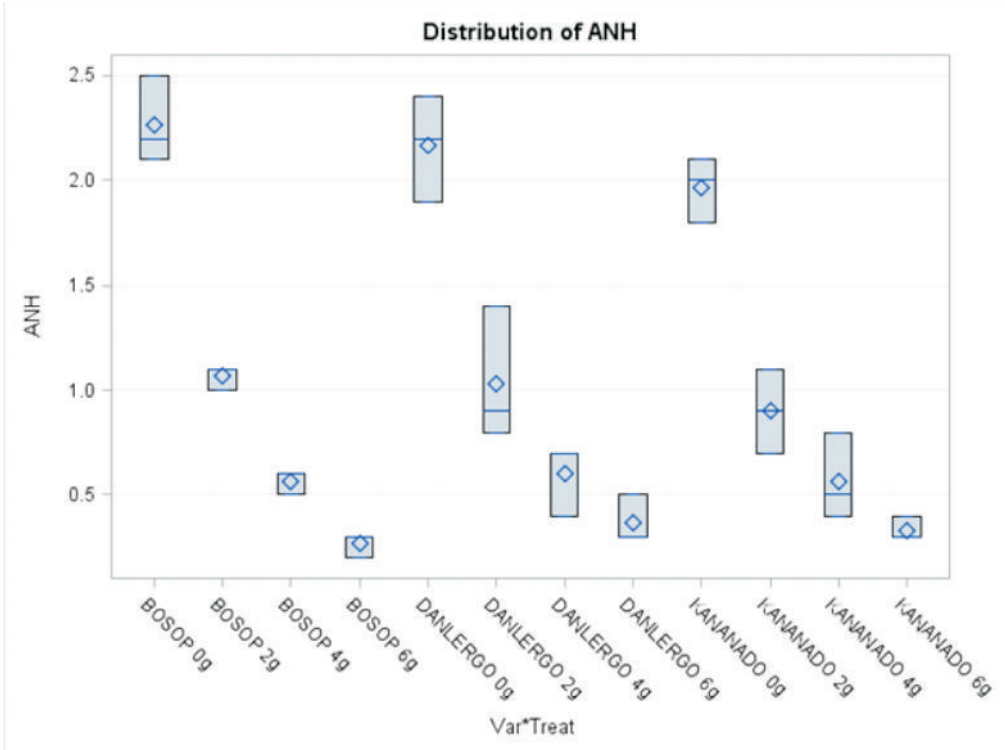


**Fig. 2**: Showing effect of variety – tobacco leaves powder levels interaction on average exit holes caused by *C. maculatus* on stored cowpeas
Legend: ANH – Average Number of Holes

## DISCUSSION

In this study, the maximum number of mortalities of adult *C. maculatus* was recorded in cowpea treated with 6g of tobacco leaves powder, while the minimum number of adult *C. maculatus* mortalities was in cowpea with zero tobacco level. The high mortality levels recorded in adult *C. maculatus* occurred due to the action of tobacco leaf powder. This finding is in line with Ofuya (43), who reported a high mortality rate for some storage insect pests when exposed to tobacco leaf powder. Heller and Mushonga (27) and Akinkurolere (5) also reported enhanced protection of stored Bambara nuts and cowpea in stores when exposed to some plant powders, especially tobacco. Mihale *et al*. (40) reported that tobacco, especially when mixed with other botanicals, is capable of controlling and lowering insect population in stored products by causing mortality in both adults and juveniles.

The study revealed that tobacco leaf powder caused mortality in juvenile *C. maculatus* on stored cowpea. This is probably due to the toxic effects of the active ingredients in tobacco leaves, as suggested by Isman (31). This agrees with the report of Lale and Alaga (38) that phytochemicals from certain botanicals, especially tobacco, are capable of suppressing oviposition and even mortality in insect pests of stored products. This finding was further

corroborated by Tiroesele *et al*. (54), who reported that juvenile mortality was higher on stored pulses treated with botanicals compared with those without the same treatments. The mortality of *C. maculatus* juveniles within the seeds suggest that the active ingredient of the tobacco leaf power penetrated the seeds

The present study revealed a higher number of exit holes in cowpeas not treated with tobacco leaves powder compared with cowpea treated with tobacco leaves powder. The presence of exit holes in cowpea signifies damage to the commodity by *C. maculatus*. This may be due to the absence of control measures in untreated cowpea that allowed insects to bore into cowpea, thereby damaging the cowpea seeds. This is in line with the finding of Tiroesele *et al*. (54), who reported that cowpea without phytochemical treatment had a higher number of exit holes when compared with those protected with phytochemicals. In the same vein, a study conducted by Uddin *et al*. (55) reported that botanicals used on some stored pulses were able to reduce the population of insects, which increased the number of undamaged pods. Ofuya (43) reported an explosion of insect pest population number in stored commodities due to the absence of treatment with tobacco leaf powder compared with cowpeas treated with tobacco leaf powder. High *C. maculatus* emergence means more exit holes and, consequently, high damage severity. This finding agrees with Tinkeu *et al*. (53), that established a relationship between emergence holes in stored pulses and damage as positively correlated

## CONCLUSION

Treating stored agricultural commodities with tobacco leaf powder may be a valuable alternative for both farmers and storekeepers in controlling *C. maculatus* infestation on stored cowpea. This study showed that dressing stored cowpea seeds with 4 and 6 grams of tobacco leaf powder was efficacious, especially on the eight day of application against the activities of *C. maculatus on stored cowpea*. These varietal/treatment-level-combinations appeared to suppress the population of *C. maculatus* on stored cowpea. This is important as it will help in controlling not only *C. maculatus*, but other insect pests of stored commodities in line of the goal of preserving the environment and beneficial and non-target organisms. It is therefore recommended that tobacco leaf powder be tested on other stored products to determine their effect in the control of insect pests.

## LITERATURE CITED

1. **Abate, T., Alene, A. D., Bergvinson, D., Silim, S., Orr, A. and Asfaw, S. 2011.** Tropical legumes in Africa and South Asia: knowledge and opportunities. TL II Research Report No. 1, ICRISAT-Nairobi vi+. 104pp.
2. **Adam, J. I. and Baidoo, P. K. 2008**. Susceptibility of five cowpea (*Vigna unguiculata*) varieties to attack by *Callosobruchus maculatus* (Fab.) (Coleoptera: Bruchidae). *Journal of the Ghana Science Association*, 10 (2): 85-92.
3. **Adebiyi, A. O. and Tedela, P. O. 2012**. Pesticidal effects of *Barbula indica* on *Callosobruchus maculatus* (Coleoptera: Bruchidae). *Nature and Science*, 10 (9): 113-115.
4. **Ahmed, B. J., Onu, I., and Mudi, L. 2009**. Field bio efficacy of plant extracts for the control of post flowering insect pests of cowpea

(*Vigna unguiculata* L.) (Walp.) in Nigeria. *Journal of Biopesticides*, 2 (1): 37-43.

5. **Akinkurolere, R. O. 2012.** Comparative effects of three plant powders and pirimiphos-methyl against the infestation of *Callosobruchus maculatus* (F.) (Coleoptera: Bruchidae) in cowpea seeds. *SOAJ of Entomological Studies*, 1 (2): 108-117.
6. **Aliyu, M., Ladan, T., Ahmed, B. I. and Abdullahi, J. 2007.** Studies on the efficacy of black soap and kerosene on the control of pod sucking bugs (*Clavigralla tomentosicollis* Stal.) on cowpea (*Vigna unguiculata* (L.) Walp.). *Emirate Journal of Food and Agriculture*, 19 (2): 8-12.
7. **Baidoo, P. K. and Mochiah, M. B. 2014.** Varietal susceptibility of improved cowpea *Vigna unguiculata* (L.) (Walp) cultivars to field and storage pests. *Sustainable Agriculture Research*, 3(2): 69-76.
8. **Baidoo, P. K., Kwansa, N. A.and Annin, C. P. 2015.** The role of seed coat and its pigmentation on the acceptance of Bambara groundnut (*Vigna subterranea* L. Verdc.) cultivars by the cowpea beetle, *Callosobruchus maculatus* (F.). *Advances in Entomology*, 3: 125-131.
9. **Bamphitlhi, T., Kesegofetse, T. and Seipati, S. 2015.** Control of cowpea weevil, *Callosobruchus maculatus* (F.) (Coleoptera: Bruchidae) sing natural plant products. *Insects*, 6: 77-84.
10. **Biswa, K., Bandyopadhyay, U., Banerjee, R. K. and Chattopadhyay, I. 2002.** Biological Activities and Medical Properties of Neem (*Azadirachta indica*). *Current Science*, 82 (11):1336-1345.
11. **Boakye, M., Mbatchou, V. C. and Khan, M. E. 2016.** Protecting cowpea seeds (*Vigna unguiculata*) against cowpea weevil (*Callosobruchus maculatus*) with unripe banana peel liquid. *Pharmaceutical Biotechnology*: *Current Research*, 1 (1): 1-6.
12. **Bressani, R. 1985.** Nutritive value of cowpea: In Cowpea Research, Production and Utilization. In S. R. Singh and K. O. Rachie (Eds) (pp. 353-359). John Wiley and Sons Ltd.
13. **Buba, M., Mwansat, G. S. and Karau, S. D. 2013.** Effect of *Azadirachta indica* (neem) powder on insect pests from two varieties of date palm fruits. *Ecophilia*, 1: 44-50.
14. **Buba, M. and Zakka, U. 2018.** Firmness and calyx covering an arsenal against *Oryzaephilus surinamensis* (Linnè, 1758) (Coleoptera: Silvanidae) infestation in stored dates (*Phoenix dactylifera* L.). *World News of Natural Sciences*, 19: 9-18.
15. **Caswel, G. H. 1981.** Damage to stored cowpea in the northern part of Nigeria. *Samaru Journal of Agricultural Research*, 5:4-5
16. **Caswell, G. H. 1984.** The value of the pod in protecting cowpea seed from attack by bruchid beetles.

*Samara Journal of Agricultural Research*, 2:49-55.

17. **Coulson, R. N. and Witter, J. A. 1984.** Forest entomology ecology and management, New York, John Willey and sons.

18. **Diouf, D. 2011.** Recent advances in cowpea, *Vigna unguiculata* (L.) Walp. "omics" research for generic improvement. *African Journal of Biotechnology*, 10: 2803-2810.

19. **Egho, E. O. 2010.** Studies on the control of major insect pests and yield of cowpea (*Vigna unguiculata* L.) (Walp.) under calendar and monitored application of synthetic chemical in Abraka, southern Nigeria. *Scholars Research Library*, 2 (4): 224-234

20. **Ekeh, F. N., Onah, I. E., Atama, C. I., Ivoke, N. and Eyo, J. E. 2013.** Effectiveness of botanical powders against *Callosobruchus maculatus* (Coleoptera: Bruchidae) in some stored leguminous grains under laboratory conditions. *African Journal of Biotechnology*, 12 (12):1384-1391.

21. **Karim, S. and Riazuddin, S. 1999.** Rice insect pests of Pakistan and their control: A lesson from past for sustainable future Integrated Pest Management. *Pakistan Journal of Biological Sciences*, 2 (2): 261-276.

22. **Kisetu, E., Nyasasi, B. T. and Nyika, M. 2014.** Effect of cropping systems on infestation and severity of field insect pests of cowpea in morogoro, Tanzania. *Modern Research Journal of Agriculture*, 1 (1): 1-9.

23. **FAO (Food and Agriculture Organization) 2005.** Cowpea production database for Nigeria, 1999-2004. Retrieved from http:/www.faostat.fao.org/.

24. **Giga, D. P., Ampofo, J. K. O., Nahdy, S., Negasi, F., Nahimana, M. and Msolla Nchimbi, S. 1992.** On-farm storage losses due to bean bruchid and farmers' control strategies. In: A report on a travelling workshop in Eastern and Southern Africa 16 September to 3 October 1992. Occasional Publication Series No. 8, 35pp

25. **Gomez, C. 2004.** Cowpea: postharvest operations. Food and Agriculture Organization of the United Nations, Rome, Italy, 46pp.

26. **GSADP (Gombe State Agricultural Development Program) 2013.** Recommended agronomic practices to farmers in Gombe state, Nigeria. Annual Report, 44pp.

27. **Heller. J. F. B. and Mushonga, J. 1995.** Bambara groundnut (*Vigna unguiculata* (L.) Verdc.). Promoting the conservation and use of underutilized and neglected crops. 9. Proceedings of the workshop on Conservation and Improvement of Bambara Groundnut (*Vigna subterranea* (L.) Verdc.), 14-16 November 1995, Harare, Zimbabwe. Institute of Plant Genetics and Crop Plant Research. Gatersleben/Department of Research and Specialist Services, Harare/International Plant Genetic Resources Institute,

Rome, Italy.

28. **IITA (International Institute for Tropical Agriculture) 2000.** Crops and farming systems. *Indian Journal of Entomology*, 32:303-310

29. **Ileke, K. D. 2012.** Bioactivity of Occidentale and *Allium sativum* (L.) powders and oil extracts against cowpea bruchid, *Callosobruchus maculatus* (Fab.). *International Journal of Biology*, 4: 96-103

30. **Ileke, K. D., Odeyemi, O. O. and Ashamo, M. O. 2012.** Insecticidal activity of *Alstonia boonei* (De Wild) powder against cowpea bruchid *Callosobruchus maculatus* (Fab.) (Coleoptera: Chrysomelidae) in stored cowpea seeds. *International Journal of Biology*, 4 (2): 125-131.

31. **Isman, M. B. 2008.** Botanical insecticides: for richer, for poorer. *Pest Management Science*, 64: 8-11.

32. **Istvan, U. 1999.** Nicotine and other alkaloids. Plant Protection Institute. Hungarian Academy of Sciences, pp29-30.

33. **Kabululu, M. S. 2008.** Cowpea (*Vigna unguiculata*) variety mixtures for stable and optimal leaf and seed yield when intercropped with maize in Central Tanzania. M.Sc. Thesis, George-August-Unuversitat, Gottingen, Germany, 75pp.

34. **Killbrew, J. B and Myrick, H. 2001.** Tobacco leaf, its culture and cure, marketing and manufacture, p, 506, orange Judd, New York 1897. Mackenzie C., Subli tobacco, p, 352, chatto and windus London 1957. NAQAS, 2001. Newsletters. ol 1 (4). 6pp.

35. **Lajide, I., Adedire, C. O., Musa, W. A. and Agele, S. O. 1998.** Insecticidal activity of powders of some Nigerian plants against the maize weevil (*Sitophilus zeamais* Motsch). *ESN Publications*, 31:227-235

36. **Lale, N. E. S. and Alaga, K. A. 2001.** Exploring the insecticidal, larvicidal and repellent properties of *Piper guineense* (Schum and Thonn) seed oil for the control of rust red flour beetle, *Tribolium casteneum* (Herbst) in stored pearl millet, *Pennisetum glaucum* (L.). *Journal of Plant Disease and Protection* 108 (3): 305-313.

37. **Lale, N. E. S. and Vidal, S. 2001.** Intraspecific and interspecific competition in *Callosobruchus maculatus* (F.) and *Callosobruchus subinnotatus* (Pic.) on stored Bambara groundnut, *Vigna unguiculata* (L.) Verdcourt. *Journal of Stored Food Research*, 37: 329-338

38. **Lale, N. E. S. 2002.** Stored-product entomology and acarology in tropical Africa. Mole Publication pp. 15-203.

39. **Lale, N. E. S. 2006.** Dictionary of entomology and acarology. Mole Publications (Nig.) Ltd. Port Harcourt, Nigeria 80pp.

40. **Mihale, M. J., Deng, A. L., Selemani, H. O., Mugisha-Kamatenesi, M., Kidukuli, A. W. and Ogendo, O. 2009.** Use of

indigenous knowledge in the management of field and storage pests around Lake Victoria basin in Tanzania. *African Journal of Environmental Science and Technology*, 3 (9): 251-259

41. **Muck, O. 2015.** Integrated pest management for rice production in Nigeria. Report on a consultancy for the CARI program, Abuja, Nigeria, February 2015. GIZ PN 11.2241.5-001.00, 19pp.
42. **Nwaubani, S. I. and Fasoranti, J. O. 2008.** Efficacy of cow bone charcoal dust in the management of maize weevil, *Sitophilus zeamais* and the lesser grain borer, *Rhyzopertha dominica* infesting stored maize grains. *Nigerian Journal of Entomology*, 25: 15-25.
43. **Ofuya, T. I. 1990.** Oviposition deterrence and ovicidal properties of some plant powders against *Callosobruchus maculatus* in stored cowpea (*Vigna unguiculata*) seeds. *Journal of Agricultural Science Cambridge*, 115:343-345.
44. **Ojumoola, A. A. and Adesiyun, A. A. 2015.** Effects of varietal differences and severity of seed damage by *Callosobruchus maculatus* (F.) on the weight and germination of some improved cowpea seeds. *Nigerian Journal of Entomology*, 31: 161-167
45. **Oluwafemi, A. R. 2012.** Comparative effects of three plant powders and pirimiphos-methyl against the infestation of *Callosobruchus maculatus* (F.) (Coleoptera: Bruchidae) in cowpea seeds. *SOAJ Entomology*, 3:4-5.
46. **Oparaeke, A. M., Dike, M. C. and Amatobi, C. I. 2005.** Botanical pesticide mixtures for insect pest management of cowpea, *V. unguiculata* (L.) Walp plants – 2. The pod borer, *Maruca vitrata* Fab. (Lepidoptera: Pyralidae) and pod sucking bug, *Clavigralla tomentosicollis* Stal (Heteroptera: Coreidae). *Agricultura Tropica et Subtropica*, 38 (2): 33-38.
47. **Raemaeker, K. 2001.** Crop Production in Tropical Africa. Ibadan, Nigeria, 372pp.
48. **Singh, S. R. 1987.** Host plant resistance for cowpea insect pest management. *Insect Science Application*, 8:765-759.
49. **Singh, S. R., Jackai, L. E. N., Dos Santos, J. H. R. and Adalla, C. B. 1990.** Insect pests of cowpea. In S. R. Singh (eds). Insect pests of tropical grain legumes. Chichester, John Wiley and Sons, pp 43-89.
50. **Singh, B. 2003.** "Improving the Production and Utilization of Cowpea as Food and Fodder" *Field Crops Research* 84: 150-169.
51. **Skerm, P. J., Cameron, D. G. and Riveros, F. 1988.** Tropical forage legumes; In FAO plant production series, 2nd ed. David Lubin Memorial Library, Rome, Italy, pp. 477-479.
52. **Tamo, M., Datinon, B., Dannon, E., Srinivasan, R., Pittendrigh, B., Dabire, C., Amadou, L, Braimah, H., Asante, S. and Biaou, E. 2016.** Biological control of cowpea insect pests: progress, challenges and opportunities. Research programme on grain

legumes. Pan-African Grain Legume and World Cowpea Conference. AVANI Victoria Falls Resort and Conference Centre, 28 February to 4 March 2016, Livingstone, Zambia.

53. **Tinkeu, L. S. N., Madou, C and Djakissam, W. 2016.** Postharvest storage systems and insect pests occurring on Bambara groundnuts (*Vigna subterranea* (L.) Verdc.) in the Sudano-Guinean savannah of Cameroon. *Journal of Entomology and Zoology Studies*, 4 (2): 167-173

54. **Tiroesele, B., Thomas, K. and Seketeme 2015.** Control of cowpea weevil, *Callosobruchus maculatus* (F.) (Coleoptera: Bruchidae), using natural plant products. *Insects*, 6:77-84

55. Uddin I. I., R. O., Azeez, K. O. and Lawal, A. A. 2017. Potentials of two bio-pesticides in the control of some field insect pests of Bambara groundnut in Ilorin. *Ethiopian Journal of Environmental Studies and Management, 10* (4): 443-450.

56. **Uzogara, S. G. and Ofunya, Z. M. 1992.** Processing and utilization of cowpea in developing countries: A review: *Journal of Food Processing and Preservation*, 16 (2): 105-147.

57. **Weber, C. 2014.** Field guide to non-chemical pest management in cowpea production. Pesticide Action Network (PAN) Germany, Hamburg. 9pp.