

100%. All formulations completely reduced the progeny (100%). In another experiment, 75, 125, 175 and 225 ppm of F2Z and F3DOTZ formulations and 300, 400, 500 and 600 ppm of diatomaceous earth alone (Celatom MN 23) were tested. After 3 days, with 175 ppm of F2Z and F3DOTZ caused adult mortalities from 99 to 100%. The DE alone at 300 ppm after 3 days only caused 80% mortality of *S. oryzae*, 60% mortality of *R. dominica* and no mortality for *S. granarius* and *T. castaneum*, and the progeny of *S. granarius* was reduced by 77%, *S. oryzae* by 78%, *R. dominica* by 92% and *T. castaneum* by 100%.

The effective concentrations of 150 ppm of F2Z, 200 ppm of F3DOTZ and 300 ppm of DE reduced bulk densities by 4.9, 3.4 and 6.4 kg/hL, respectively.

These new formulations were effective at controlling insects better than DE alone, yet do not reduce the bulk density as much as DE alone. Further testing is required to determine if these formulations should be brought to market; duration of efficacy, cost of formulations, testing for their effect on non-target organisms, human safety and effect on end-use quality.

**Keywords:** diatomaceous earth, synergy, natural, mortality, bulk density

## References

- ATHANASSIOU, C.G., KORUNIC, Z., 2007. Evaluation of two new diatomaceous earth formulations, enhanced with abamectin and bitterbarkomycin, against four stored-grain beetle species. *Journal of Stored Products Research* **43**, 468-473.
- ATHANASSIOU, C.G., KORUNIC, Z., VAYIAS, B.J., 2009. Diatomaceous earths enhance the insecticidal effect of bitterbarkomycin against stored-grain insects. *Crop Protection* **28**, 123-127.
- KORUNIC, Z., 1998. Diatomaceous earths, a group of natural insecticides. *Journal of Stored Products Research* **34**, 87-97.
- KORUNIC, Z., FIELDS, P.G., KOVACS, M.I.P., NOLL, J.S., LUKOW, O.M., DEMIANYK, C.J., SHIBLEY, K.J., 1996. The effect of diatomaceous earth on grain quality. *Postharvest Biology and Technology* **9**, 373-387.
- KORUNIC, Z., ROZMAN, V., LIŠKA, A., LUCIĆ, P., 2017. Laboratory tests on insecticidal effectiveness of disodium octaborate tetrahydrate, diatomaceous earth and amorphous silica gel against *Sitophilus oryzae* (L.) and their effect on wheat bulk density. *Poljoprivreda* **23**, 3-10.
- LIU, S.Q., SCOTT, I.M., PELLETIER, Y., KRAMP, K., DURST, T., SIMS, S.R., ARNASON, J.T., 2014. Dillapiol: A pyrethrum synergist for control of the Colorado potato beetle. *Journal of Economic Entomology* **107**, 797-805.
- SUBRAMANYAM, B., ROESLI, R., 2000. Inert dusts, in: Subramanyam, B., Hagstrum, D.W. (Eds.), *Alternatives to Pesticides in Stored-Product IPM*. Kluwer Academic Publishers, Boston, Massachusetts, USA, pp. 321-380.
- WARE, G.W., WHITACRE, D.M., 2004. *The Pesticide Book*, Sixth Ed ed. MeisterPro Information Resources, Willoughby, Ohio.

## Protecting Stored Maize Grain Against the *Sitophilus Zeamais* with Rice Husk Ash

**Joseph O. Akowuah\***, **George Obeng-Akrofi**, **Emmanuel Minka**, **Alberta Barima**

Department of Agricultural and Biosystems Engineering, Kwame Nkrumah University of Science and Technology, Kumasi, Ghana

Corresponding author\*: akowuahjoe@yahoo.co.uk

DOI 10.5073/jka.2018.463.254

## Abstract

Maize weevil (*Sitophilus zeamais*) is an important insect that affect the maize grain on the field and in storage. There are several ways of controlling this insect but the most commonly used is the use of chemicals. Although these chemicals are very effective, they are often expensive and not available to poor rural farmers resulting in high post-harvest losses of their harvested grains. In this study, the potential of using rice husk ash (RHA) as a protectant against maize weevil during storage was investigated. Cultured maize weevils were introduced into 400g of maize admixed with RHA at concentrations of 5g, 10g and 20g. A control set-up of both Actellic 50EC and no RHA was set-up to compare the effect of the ash treatments on weevil mortality, re-emergence and grain damage. The treatments were replicated and set-up in the lab at room temperature condition. Results showed that, 100% mortality was observed for the Actellic 50EC treatment 5days after application. However, there was no significant difference ( $p > 0.01$ ) after 60 days of storage between the 20g RHA application and the Actellic 50EC relative to weevil mortality, emergence and grain damage. With the 20g RHA admixture recording the highest mortality and suppression effect on adult weevil emergence as well as the lowest grain damage, the use of RHA can provide a significant economic advantage to farmers for storage of maize in tropical developing countries if reliable recommendations on application rate can be made for the protection of stored maize.

**Keywords:** Maize storage; maize weevil; rice husk ash; protectant, mortality

## Introduction

Being an integral component of staples in Sub-Saharan Africa, maize is considered as an essential source of cash for farmers. It is well known to be one of the few crops that have profound effects on the livelihoods of people in Sub-Saharan Africa. There is no doubt that in Ghana, more than half of the area of land allocated for cereal production is being used for maize production (FAOSTAT, 2010). The adverse effect of climate change has led to the decrease in food output, of which maize constitute a significant part. This has caused a negative effect on the socio-economic lives of farmers. There is therefore, the need for innovative and well-adaptable methods for conserving the scarce food which is being produced by farmers from this part of the world.

In Ghana, maize like all other cereals, are stored in bags. In as much as initial pest infestation may occur in the field, the environmental conditions prevailing in traditional storage systems favour the survival and emergence of storage pests such as weevils. Indeed, weevils are often identified as one of the major problems causing loss of stored grain in Africa. An estimated percentage of 5 to 10 % maize is lost due to weevil attack (Booyesen, 1983; Mashingaidze, 1994; Gadzirayi *et al.*, 2006). This poses a risk to food security in Ghana and other developing countries in Sub-Saharan Africa.

The use of synthetic insecticides has proven to be effective as reported by Ogunleye and Adefemi (2007); Obeng-Ofori and Amiteye (2005) and Asawalam *et al.* (2007). In Ghana, two main chemicals: aluminium phosphide (phostixin) and actellic 50EC are used conventionally to treat/protect stored maize against the maize weevil. However, major drawbacks to the use of such insecticides such as the development of insect resistant strains and their toxic residues getting into food of animals and man are limiting their usage by farmers and other target customers. Again, the inimical macro-economy has resulted in high prices for these products and has therefore, sprouted the need for identifying other methods of preserving maize grains. Alternative methods such as the use of powdered plant parts and plant extracts have yielded positive results in comparison to the use of some synthetic insecticides (Cobbinah and Appiah-Kwarteng, 1989; Jembere *et al.*, 1995; Lajide *et al.*, 1998; Asawalam and Adesiyani, 2001; Asawalam *et al.*, 2007 and Udo, 2011). Aside these alternatives being eco-friendly, they are cheaper than chemical insecticides. Also, their availability for use is very easy since the materials used are readily available at farming areas.

The use of rice husk ash in storing maize for protection against storage pests is eminent in Ghana. However, information regarding its usage and effects on its protection of stored maize against *Sitophilus zeamais* attack is unknown. Therefore, there is the need for more study to be done in this direction. The present work therefore was designed to investigate the effectiveness of rice husk ash (RHA) in controlling *Sitophilus zeamais* in stored maize grain as compared to Actellic %0EC.

## Materials and Methods

### Culture of maize weevils

Species of *Sitophilus zeamais* was obtained from a sample of maize from the Ayigya market of Kumasi in Ashanti Region, Ghana. The insects were kept in Kilner jars at room temperature in the Entomology laboratory of the Agricultural faculty, Kwame Nkrumah University of Science and Technology (KNUST), Kumasi. The weevils were cultured for a period of 12 weeks.

### Preparation of ash

Rice husk was collected from a rice farm at Besease, a rice farming community in Ashanti Region, Ghana. The husk was burnt into ash using a gasifier. On cooling, the ash was pulverized and kept in air tight bags at room temperature.

### Moisture content determination

The maize variety, *Obaatampa*, was obtained from the Ministry of Food and Agriculture, MOFA, Kumasi at a moisture content of 13%. This was confirmed using the oven method (ISO 6540-1980).

### Samples and treatments

Visual inspection was made to remove infested maize from the sample in use. 400g of uninfested maize was weighed into 15 plastic containers. Different concentrations (1.25%, 2.5% and 5% wt/wt maize grains) of rice husk ash were introduced in nine of the containers containing 400g of the maize samples. Each treatment, T5, T10, T20, TCH and TC representing 1.25 % of RHA, 2.5 % of RHA, 5% of RHA, Chemical (Actellic 50 EC) application and Control (no chemical/ash applied) respectively, were replicated three times. 20 species of the cultured *Sitophilus zeamais* (10 males and 10 females) were introduced into each container using forceps.

### Experimental setup

The complete randomized design as shown in Tab. 1, with five treatments and three replicates were used in setting up experiment.

**Tab. 1** Experimental setup in laboratory

1 <b>T5</b>	2 <b>T10</b>	3 <b>TCH</b>	4 <b>T20</b>	5 <b>TC</b>
6 <b>T10</b>	7 <b>TCH</b>	8 <b>T20</b>	9 <b>TC</b>	10 <b>T5</b>
11 <b>T20</b>	12 <b>TC</b>	13 <b>T5</b>	14 <b>T10</b>	15 <b>TCH</b>

### Mortality, progeny and damage assessment

Number of dead weevils in each container was recorded after the first five days of set-up and for every other week for two months. Mortality rate was then calculated using Equation 1 by Asawalam (2007).

$$M_r = \frac{d_w}{d_w} \times 100 \dots\dots\dots \text{Equation (1)}$$

Where

$M_r$ -mortality rate

$D_w$ -total number of weevils

$D_w$ -number of dead weevil

Percentage damage made on maize by the weevils was calculated using Equation 2 as used by Asawalam (2007).

$$\text{Damage (\%)} = \frac{\text{number of damage grains}}{\text{total number of grains in containe}} \times 100 \dots\dots\dots \text{Equation (2)}$$

Weevil Perforation Index (WPI) is a damage assessment in which the number of perforations in treated grains is compared to that of the control. Equation 3 was used to determine WPI during the experiment.

$$WPI = \frac{Nps}{Npc} \times 100 \dots\dots\dots \text{Equation (3)}$$

Where

WPI- Weevil Perforation Index

Nps - Number of perforated seeds with treatment.

Npc - Number of perforated seeds in the control.

WPI > 50 = negative protectant of plant material tested (i.e. enhancement of infestation by the weevil)

WPI < 50 = positive protectant (i.e. prevention of infestation by the weevil)

### Data analysis

Using an analysis of variance, the number of dead weevils was investigated to determine whether there were any significant differences in the numbers of live and dead weevils as well as the quality

of maize grain used. A significance level of 1% was used for all analysis. A one-way ANOVA was set up for the investigation.

## Results

### Mortality and suppression of adult emergence

The comparison of the *S. zeamais* mortality in the four treatments plus the control is shown in Tab. 2. A significant difference ( $p < 0.01$ ) was recorded by the treatments on the average number of dead weevils monitored every other week in the storage containers for a period of 2 months. Apart from the control, all treatment recorded more than 80 % mortality. TCH had great effect of 100 % on the mortality of *S. zeamais*. This was followed by T20, T10 and T5 of mortality rates 98 %, 95 % and 90.9 % respectively. TC witnessed an uncontrollable emergence of adult weevils with a mortality of 52.9 %. Comparing the results from TCH to T20 and T10 treatments, it was observed that the effect on population growth of the weevils can be likened to that of TCH since there was no significant difference ( $p > 0.01$ ) between the two rice husk ash treatments and the chemical treatment.

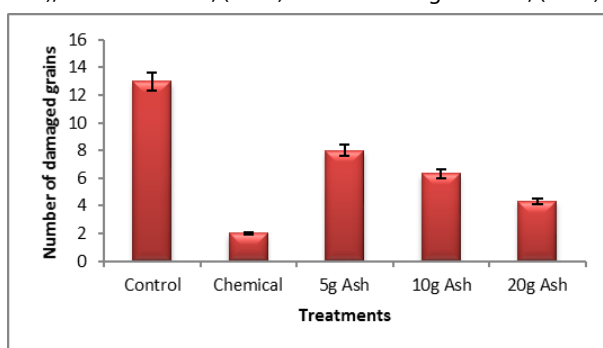
**Tab. 2** Mortality of *S. zeamais* from maize with different treatments

Treatment	Mortality*
TC	52.9a
TCH	100bc
T5	90.9d
T10	95c
T20	98c
L.S.D.	8.09

\* Results are means of four replicates of twenty insects each. Mean values with same variables indicates no significant difference ( $p > 0.01$ )

### Damaged grains

The number of damaged grains recorded after the two months of storage is shown in Fig. 1. 100 grains sample was taken from each of the 15 containers for this analysis. TC had the greatest damage of 13 damaged grains. This was followed by T5, T10 and T20 with 8, 6.3, 4.3 and 2 damaged grains respectively. This shows that the ash as compared to the chemical also had an adverse effect on the weevils making them uncomfortable, hence less damage on grain. Similar results were witnessed by Mazarin et. al. (2016); Otitudun et. al., (2017) and Goudougou et. al., (2018).



**Fig. 1** Effect of different treatments on the number of damaged grains by *S. zeamais*

### Weevil Perforation Index (WPI)

Weevil Perforation Index directly relates to weight loss and damage assessment. All treatments other than TC had WPI  $< 50$  resulting in positive protectant of maize grains from *Sitophilus zeamais* attack. Hence, all treatments had the capabilities of preventing maize from the infestation by *S.*

*zeamais*. TCH had the least WPI of 15.38 followed by T20, T10 and T5 of 33.31, 40.69 and 58.54 WPI respectively. TC had WPI of 100 which means that it is ineffective or inefficient to store maize without any treatment (Asawalam et al., 2007).

**Tab. 3** WPI of different treatments by *S. zeamais*

Treatment	WPI
TC	100
TCH	15.38
T5	48.54
T10	40.69
T20	33.31

## Discussion

It is clear that the rice husk ash treatment used for the study gave positive results in terms of protecting maize grains from the attack of *S. zeamais*. Evidently, the rice husk ash treatments had an obvious effect on the population growth rate of the weevils, their re-emergence, WPI and the damage caused by *S. zeamais* to the maize grain. It was observed that, high application rate of 20g rice husk ash per 400g maize sample had a low mortality, low WPI and less damage to grains as it significantly suppressed the emergence of adult *S. zeamais* when compared to the control.

Results suggest that the weevils would prefer to avoid maize grains treated with the ash. The results showed that the ash had some degree of insecticidal activities. Insecticidal property of any plant material would depend on the active constituents of the plant material. Okonkwo and Okoye (1996); Ogban et al. (2016) reported that *P. guineense* contains piperine and chavicine which are insecticidal. Idoko and Adesina (2012) also indicated that piperidine and alkaloids as the major active components in *P. guineense* seeds and suggested that *S. zeamais* development was adversely affected by grains treated with these powders than the control. The ability of these plant powders to cause mortality of *S. zeamais* adults on maize grains can be attributed to contact toxicity of the powders on the weevil. Though the lethal action of rice husk ash on maize weevils was not investigated, Otitodun et al., (2017) reports that the main ingredient of rice husk ash which is silica (SiO<sub>2</sub>) accounts for 87.1 % of the total content and has almost the same composition as diatomaceous earth which is effective in controlling pests of stored grain.

The rice husk ash is reported to contain large number of needle-like particles that are probably obtained from the setae covering the outer surface of the rice hull. These needle-like particles may have caused some skin irritations to the weevils which might cause death. It is believed that inert substances like the rice husk ash generally cause a loss in body moisture due to the presence of silica.

## Conclusion

From this study, it can be concluded that rice husk ash has the potential in controlling the *S. Zeamais* in stored maize. It was observed that after the 120-125 days of storage, the incidence of weevils was lower in the containers with the higher concentration of ash (20g). This indicates that there is an increasing suppression on the population growth of the weevils with increasing concentration. This may be attributed to the toxic effect and unfavourable conditions created in the containers with the higher levels of rice husk ash. Hence, rice husk ash has the potential of controlling the damaging effects of *S. Zeamais* on maize grains in storage. Due to its eco-friendly and indigenous nature, rice husk ash can be adopted by small-scale farmers in rural communities in Ghana and some parts of Sub-Saharan Africa.

## References

- ASAWALAM, E. F. AND ADESIYAN S. O. 2001. POTENTIALS OF OCIMUM BASILICUM (LINN.) FOR THE CONTROL OF SITOPHILUS ZEAMAI (MOTSCH), THE NIGERIAN AGRICULTURAL JOURNAL 32: 195 – 201.

- ASAWALAM, E. F., EMOSAIRUE S.O., EKELEME, F. AND WOKOCHA, R C., 2007. INSECTICIDAL EFFECTS OF POWDERED PARTS OF EIGHT NIGERIAN PLANT SPECIES AGAINST MAIZE WEEVIL *SITOPHILUS ZEAMAI* MOTSCHULSKY (COLEOPTERA: CURCULIONIDAE). ELECTRONIC JOURNAL OF ENVIRONMENTAL, AGRICULTURAL AND FOOD CHEMISTRY. ISSN: 1579-4377.
- BOOYSEN, G., 1983. SENIOR SECONDARY AGRICULTURAL SCIENCE, JUTA PUBLISHING HOUSE, JOHANNESBURG, SA.
- COBBINAH, J.R AND APIIAH-KWARTENG J. 1989. EFFECTS OF SOME NEMO PRODUCTS ON STORED MAIZE WEEVIL, *SITOPHILUS ZEAMAI* (MOTSCH.). INSECT SCIENCE AND ITS APPLICATION 1: 89-92
- FAOSTAT, 2010. "FAO STATISTICAL DATABASE", AVAILABLE AT: [HTTP://FAOSTAT.FAO.ORG/SITE/291/DEFAULT.ASPX](http://faostat.fao.org/site/291/default.aspx) (ACCESSED 15 APRIL 2018).
- GADZIRAYI, C.T., MUTANDWA E., CHIKUVIRE T.J., 2006. EFFECTIVENESS OF MAIZE COB POWDER IN CONTROLLING WEEVILS IN STORED MAIZE GRAIN. AFRICAN STUDIES QUARTERLY. SUMMER.
- GOUDOUNGOU, J.W., NUKENINE, E.N., SUH, C., GANGUÉ, T. AND NDJONKA, D., 2018. EFFECTIVENESS OF BINARY COMBINATIONS OF *PLECTRANTHUS GLANDULOSUS* LEAF POWDER AND *HYMENOCARDIA ACIDA* WOOD ASH AGAINST *SITOPHILUS ZEAMAI* (COLEOPTERA: CURCULIONIDAE). AGRICULTURE & FOOD SECURITY, 7(1), p.26.
- IDOKO, J.E., AND ADESINA, J.M., 2012. EVALUATION OF THE POWDERS OF *PIPER GUINEENSE* AND PIRIMIPHOS- METHYL F FOR THE CONTROL OF COWPEA BEETLE *CALLOSOPHUS MACULATUS* (F.). JOURNAL OF AGRICULTURAL TECHNOLOGY 8(4): 1365-1374
- ILBOUDO, Z., DABIRÉ-BINSO, C.L., SANKARA, F., NÉBIÉ, R.C.H. AND SANON, A., 2015. OPTIMIZING THE USE OF ESSENTIAL OILS TO PROTECT STORED COWPEAS FROM *CALLOSOPHUS MACULATUS* (COLEOPTERA: BRUCHINAE) DAMAGE. AFRICAN ENTOMOLOGY, 23(1), pp.94-100.
- JEMBERE, B., OBENG- OFORI D. AND HASSANALI A. 1995. PRODUCTS DERIVED FROM THE LEAVES OF *OCIMUM KILMANDSCHARICUM* (LABIATAE) AS POST HARVEST GRAIN PROTECTANTS AGAINST THE INFESTATION OF THREE MAJOR STORED INSECT PRODUCT PESTS. BULLETIN OF ENTOMOLOGICAL RESEARCH 85: 361-367.
- LAJIDE, L., ADEDIRE C. O., MUSE W. A. AND AGELE S. O. 1998. INSECTICIDAL ACTIVITY OF POWDERS OF SOME NIGERIAN PLANTS AGAINST THE MAIZE WEEVIL (*SITOPHILUS ZEAMAI* "MOTSCH") ENTOMOLOGICAL SOCIETY NIGERIA OCCASIONAL PUBLICATIONS 31: 227 – 235.
- MASHINGAIDZE, K., 1994. MAIZE RESEARCH AND DEVELOPMENT. IN ZIMBABWE'S AGRICULTURAL REVOLUTION: MAIZE RESEARCH AND DEVELOPMENT, pp. 208-212, (RUKUNI, M. AND EICHER, C. EDS.). UNIVERSITY OF ZIMBABWE PUBLICATIONS, HARARE, ZIMBABWE.
- MAZARIN, A., NUKENINE, E.N., NIU, C. AND VINCENT, F.V., 2016. SYNERGISTIC EFFECTS OF WOOD ASH AND ESSENTIAL OIL ON FECUNDITY, PUPAL ECLOSION AND ADULT MORTALITY OF *CALLOSOPHUS MACULATUS* (COLEOPTERA: BRUCHIDAE) COWPEA SEED WEEVIL. AMERICAN JOURNAL OF EXPERIMENTAL AGRICULTURE, 11(6).
- OBENG-OFORI D. AND AMITEYE S., 2005. EFFICACY OF MIXING VEGETABLE OILS WITH PIRIMIPHOS-METHYL AGAINST THE MAIZE WEEVIL, *SITOPHILUS ZEAMAI* MOTSCHULSKY IN STORED MAIZE. JOURNAL OF STORED PRODUCTS RESEARCH. 41: 57-66.
- OGBAN, E.I., UKPONG, I.G., OKU, E.E., USUA, E.J., UDO, S.E., OGBECHE, J.O. AND AJANG, R.O., 2015. POTENTIALS OF TWO INDIGENOUS PLANTS POWDER FOR THE CONTROL OF STORED MAIZE WEEVIL, *SITOPHILUS ZEAMAI* (MOTSCHULSKY). AM J EXP AGRIC, 5(1), pp.12-17.
- OGUNLEYE R.F. AND ADEFEMI S.O., 2007. EVALUATION OF DUST AND METHANOL EXTRACTS OF *GARCINIA KOLAE* FOR THE CONTROL OF *CALLOSOPHUS MACULATUS* (F.) AND *SITOPHILUS ZEAMAI* (MOTS). JOURNAL OF ZHEJIANG UNIVERSITY SCIENCE. 8(12): 912-916
- OKONKWO, E. U. AND OKOYE, W. I. (1996). THE EFFICACY OF FOUR SEED POWDERS AND THE ESSENTIAL OILS AS PROTECTANTS OF COWPEA AND MAIZE GRAINS INFESTATION BY *CALLOSOPHUS MACULATUS* (FABRICIUS) (COLEOPTERA: BRUCHIDAE) AND *SITOPHILUS ZEAMAI* (MOTS.) (COLEOPTERA: CURCULIONIDAE) IN NIGERIA. INTERNATIONAL JOURNAL OF PEST MANAGEMENT, 42 (3): 143-146.
- OTITODUN, G.O., OPIT, G.P., NWAUBANI, S.I. AND OKONKWO, E.U., 2017. EFFICACY OF RICE HUSK ASH AGAINST RICE WEEVIL AND LESSER GRAIN BORER ON STORED WHEAT. AFRICAN CROP SCIENCE JOURNAL, 25(2), pp.145-155.
- UDO, I. O., 2011. PROTECTANT EFFECT OF PLANT OILS AGAINST COWPEA WEEVIL (*CALLOSOPHUS MACULATUS*) ON STORED COWPEA (*VIGNA UNGUICULATA*). ARPN JOURNAL OF AGRICULTURAL AND BIOLOGICAL SCIENCE. VOL. 6, NO. 12, 58-61.

## Effectiveness of binary combinations of *Plectranthus glandulosus* leaf powder and *Hymenocardia acida* wood ash against *Sitophilus zeamais* (Coleoptera: Curculionidae)

Goudougou J. W.<sup>1\*</sup>, Nukenine Elias Nchiwan <sup>2</sup>, Suh Christopher<sup>3</sup>, Gangué T.<sup>1</sup>, Ndjonka D.<sup>2</sup>

<sup>1</sup>Department of Biological Sciences, Faculty of Science, University of Bamenda, P. O. Box 39 Bambili, Cameroon

<sup>2</sup>Department of Biological Sciences, Faculty of Science, University of Ngaoundere, P. O. Box 454 Ngaoundere, Cameroon

<sup>3</sup>Coordination of annual crops, IRAD Nkolbisson, P.O. Box 2123 Yaounde, Cameroon.

\*Corresponding author: winigoudougou@yahoo.fr, (+237) 696 843 042 / 678 606 201

DOI 10.5073/jka.2018.463.177

### Abstract

Combinations of botanicals could enhance biological activity against insects. This in turn, will reduce amount of botanical used in storage protection. In this issue, the bioassay was carried out on *Sitophilus zeamais* to assess the effectiveness of binary combinations of *Hymenocardia acida* wood ash and *Plectranthus glandulosus* leaf powder regarding adult toxicity, progeny inhibition, and reduction of damage and germination ability. *Plectranthus glandulosus* leaf powder, *H. acida* wood ash and their binary combinations significantly induced mortality of *S. zeamais* adult ( $P < 0.0001$ ). The higher mortality rate was achieved by the highest content (40 g/kg) of *H. acida* wood ash (94.66%) and 25PG75HA (94.59%) within 14 days of exposure. The combinations of *P.*