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Evaluation of selected indigenous pesticidal plant powders against stored maize and cowpeas insect pests

L. CHIKUKURA[1], B. M. MVUMI[1], R. CHIKONZO[1] & C. CHENZARA[2]
[1]Department of Soil Science and Agricultural Engineering, Faculty of Agriculture, University of Zimbabwe, P.O. Box MP167, Mount Pleasant, Harare, Zimbabwe
[2]Institute of Agricultural Engineering, P.O. Box 330 Borrowdale, Harare, Zimbabwe
Corresponding author: mvumibm@hotmail.com; mvumibm@agric.uz.ac.zw

Abstract The insecticidal properties of powders of *Lippia javanica* dried leaves, and wood of the *Spirostachys africana* wood were evaluated on-station to determine the efficacy and optimise their use in reducing maize grain storage losses at concentrations of 2% and 5% w/w compared to Actellic Super dust (ASD) at 0.05% w/w and an untreated control. On maize, *L. javanica* 5% provided the best control among the pesticidal plants and showed potential to control grain damage to between 21% - 33% compared to about 40% in the untreated control by week 24. On cowpeas (*Vigna unguiculata*), the same treatments were applied, and an additional treatment of *Combretum imberbe* wood ashes at 2% and 5% w/w was included. The *C. imberbe* 5% treatment was equally effective as ASD in reducing grain damage in cowpeas over a 16 week storage period. The results are discussed in the context of sustainable use of the plants by resource poor farmers.

Key words: Grain protection, indigenous pesticidal plants, resource-poor farmers, storage insect pests

Introduction

Smallholder farmers throughout sub-Saharan Africa (SSA) have serious problems in protecting their harvested crops from insect pest infestation during storage. Successful storage of grain commodities throughout a storage season has often been hampered by insect pests, the principal pests being *Sitophilus* spp, *Callosobruchus* spp., *Prostephanus truncatus* and *Tribolium* spp. Belmain & Stevenson (2001) noted that storage losses due to storage insects is a serious threat to food security and household incomes. Chemical pesticides have often provided the first line of defence against insect pests of grain. Synthetic pesticide treadmills and inefficiencies have resulted in increased input costs for resource poor farmers in developing countries. The need for cheaper but effective options for combating insect pests has resulted in the resurgent use of plant materials where the majority of the farmers in developing countries are resource constrained. In southern Africa, Zimbabwe included, farmers are using a variety of pesticidal plants in their fields, in grain and in vegetables with varying success (Nyirenda *et al*., 2011; Kamanula *et al.*, 2011) though only a few plant species have been commercialised (Mwine *et al.*, 2011). Full documentation and scientific evaluation of plants for pest management purposes is still lacking, though medicinal plant research has received much attention.

Three indigenous plants already being used by farmers as grain protectants were selected. These plants include the shrub *L. javanica* whose extracts have potential pest repellency (Mwangi *et al.*, 1992); *Spirostachys africana*, traditionally a medicinal painkiller for toothache; and *Combretum imberbe* used to relieve coughs, colds and chest complaints among a variety of other medicinal uses (Coates Palgrave, 2002). In the current study, the efficacy of the pesticidal plants against stored grain insect pests prevalent in smallholder farmer stores was investigated in order to validate and optimise their use in reducing grain storage losses due to insects.

Materials and Methods

Trial site and experimental design. The on-station trials were conducted at Hatcliffe Farm in Harare with the following average annual conditions: temperatures 17.95°C, 55% RH, annual rainfall 825 mm. The experiment was conducted for 24 weeks and coincided with the commencement of the typical storage season in Zimbabwe.

In this study, 20 kg and 10 kg of clean and untreated grains of maize and cowpeas, respectively, were used per treatment. The grains were kept in polypropylene bags and then stored in improved brick and grass thatched smallholder granaries.

The treatments were as follows: *S. africana, L. javanica* at 2% and 5% w/w and Actellic Super Dust (ASD) at label rate (positive treatment) and an untreated control being the negative control. In cowpeas there were eight treatments, *S. africana, L. javanica* and *C. imberbe* at 2% and 5% w/w and ASD at label rate and an untreated control. Each treatment was replicated 3 times (in both maize and cowpeas). All the treatments were laid out in a Randomised Complete Block Design (RCBD).

The plant materials were shade-dried then ground using a Thomas Wiley Laboratory Mill separately and sieved using a 150 *u*m sieve to obtain finer powders. The plant powders were applied on grain as admixtures.

Grain sampling and sample analysis. Approximately 1 kg of maize and 500 g of cowpeas were collected at trial set-up and subsequent sampling was at 8-week intervals using hollow bag spears. The gravimetric method was used to determine the moisture content of the grain based on replicates of 50 g taken from each sample. Moisture content (mc) was calculated as follows:

$$\% \, mc \, (wb) = \frac{(Wwet - Wdry)}{Wwet} * 100$$

Where: *%mc (wb)* = moisture content on a wet basis; *Wwet* = weight of wet sample; *Wdry* = weight of dry sample

Insect count and grain damage assessment. The remaining samples were weighed and sieved through a nest of sieves (2 to 0.5 mm) to remove any trash. Adult insects, live and dead, were identified and recorded according to their species within a seven-day period from the start of sampling. A riffle divider was used to subdivide the remaining clean grain into approximately four equal portions out of which three portions were randomly selected for grain damage assessment. Percentage damage levels were calculated using the following formula:

$$\% \, D = (Nd/N) * 100$$

Where *%D* = percentage damage; *Nd* = number of damaged grain; *N* = Total number of grain countered

Data analysis. Insect mortality rates were subjected to logarithmic [$\log_{10}$] transformations to normalize them before analysis. A two way ANOVA for the effect of treatment and time was used. Bonferroni's test was used to separate treatment means at 5% of level of significance.

Results

Cowpeas. There was a significant difference (P<0.05) in grain damage amongst the treatments throughout the 24 week storage period with considerable grain damage appearing in week 16. Grain damage was significantly correlated to storage period ($r^2 = 0.9479$) with mean grain damage increasing with time. ASD provided the best protection against grain damage of 13.22%, followed by *C. imberbe* 5% at 18.93% (Fig. 1a). *S. africana* at all

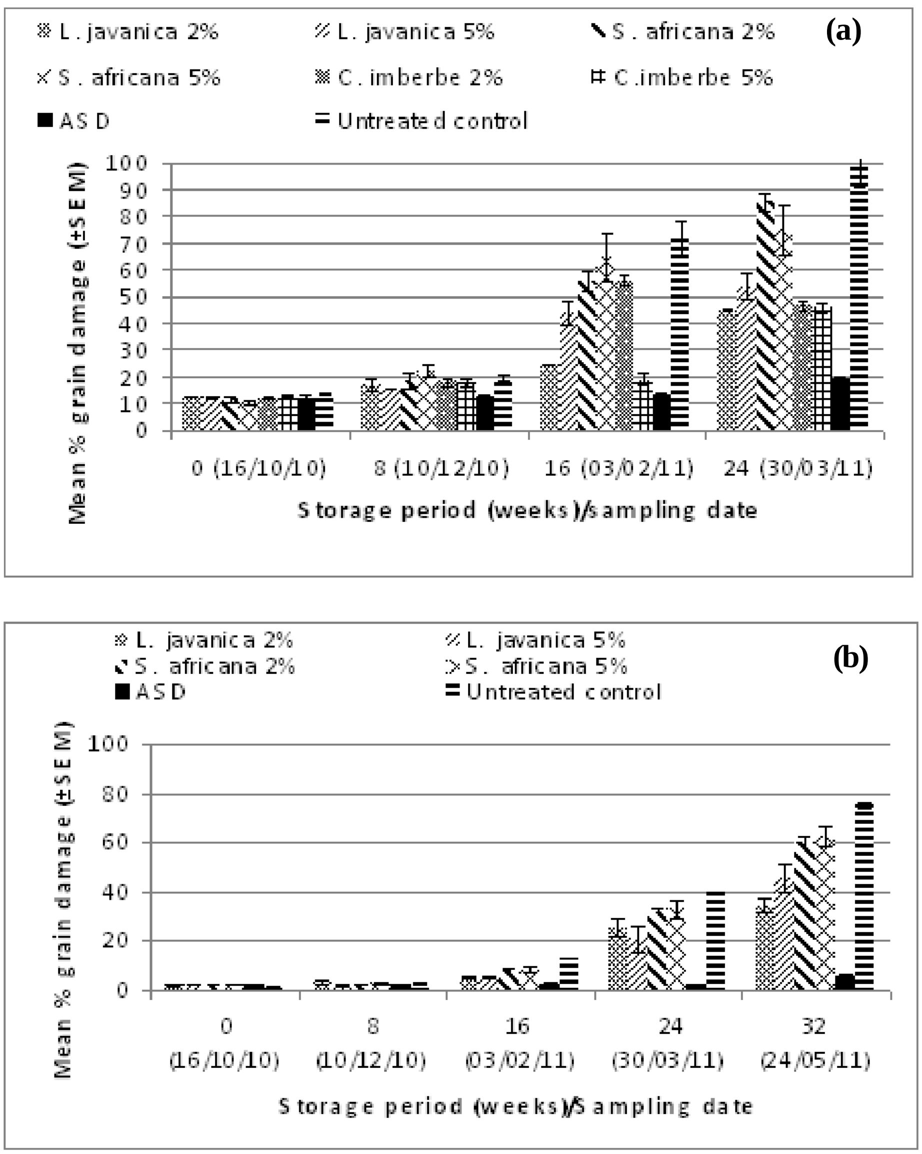
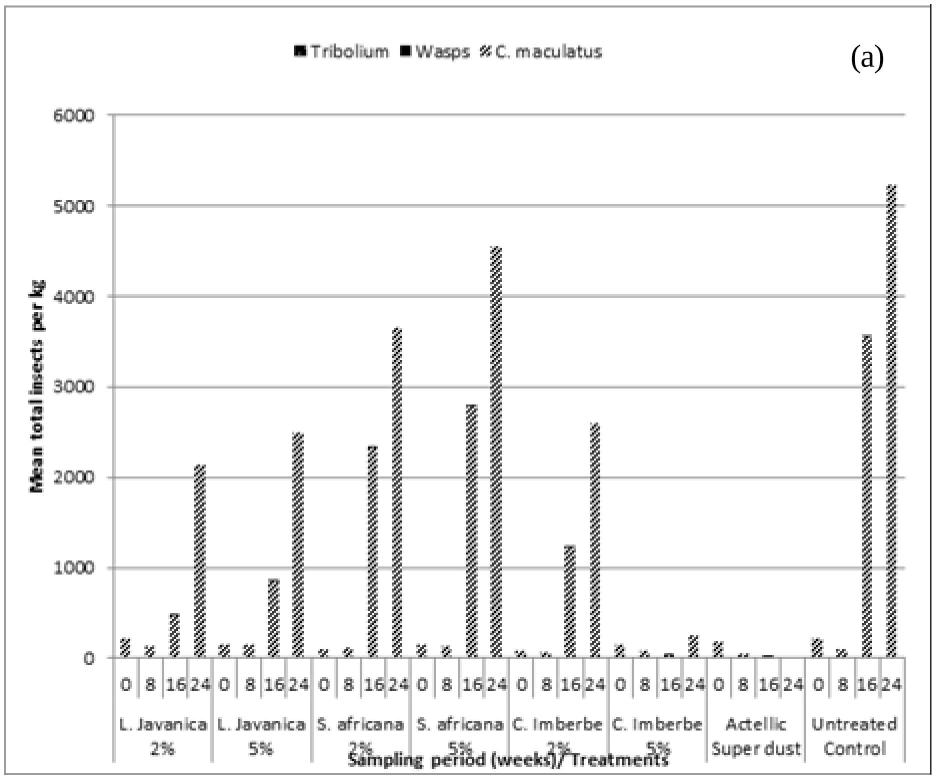


Figure 1. Mean percentage grain damage (± SEM) in untreated and treated (a) cowpeas and (b) maize (n=3).

treatment levels had significant differences with the other plant materials (P<0.05) and also *S. africana* treatments had the highest grain damage of above 74%, though the untreated control had the highest of 97%.

There was a strong relationship between mean number of insects per kg (Fig. 2 a) and the mean percentage grain damage (r^2= 0.956). Insect populations increased significantly in week 16 with all treatments having a population of over 2000 insects (Fig 2a).

Maize. Grain damage increased with storage time, but to less than 13% in all treatments by week 16 (Fig. 1a). *L. javanica* 5% provided the best protection when the pesticidal plants were compared against each other though there were no significant differences between *L. javanica* 2% and 5% (P>0.05). *S. zeamais*, *P. truncatus*, *S. cereallea and T. castaneum* were the major insect species found in the grain during the 24 week period. In week 24, insect activity increased heavily with *S. africana* treatments



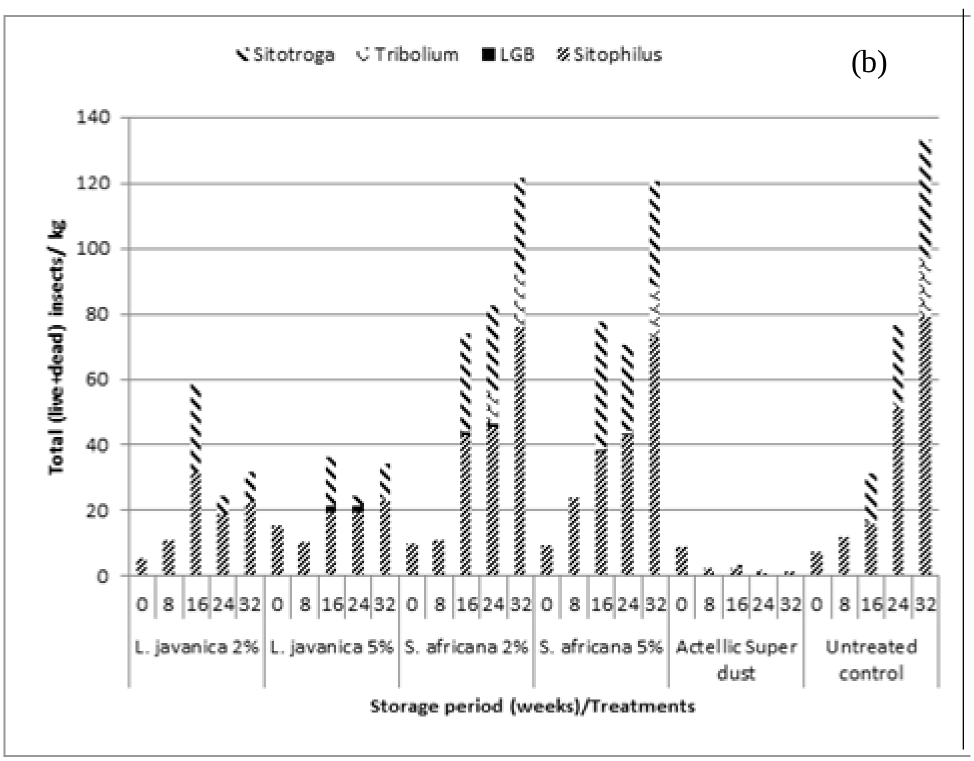


Figure 2. Mean percentage grain damage (± SEM) in untreated and treated (a) cowpeas and (b) maize (n=3); ASD = Actellic Super Dust.

having a higher number of mean total live insects (160 per kg) more insects than the untreated control (Fig. 2b).

Discussion

The pesticidal plant materials showed varied efficacy as grain protectants. In cowpeas, *L. javanica* 2% and *C. imberbe* 2% and 5% ash provided the best protection against grain damage when all the pesticidal plants were compared. *S. africana* at all treatment levels failed to provide the needed protection refuting farmer claims of insect repellency since the grain treated with *S. africana* was highly infested.

Farmers normally use the plant as dried wood chips stuck in grain (Mvumi *et al*., 1995). This could have been an issue of the plant attracting insects despite the claimed repellence. Studies by Fields *et al*. (2000) have shown that plant derivatives and other pesticidal plants, known to have repellent properties, attract insects. Leaves of *A. indica* and *Chamaecrista nigricans* have been reported to be non-effective or to have a negative influence on *Callosobruchus maculatus* (Boeke *et al*., 2004) yet most literature state that these two pesticidal plants have repellent effects. The attractant effects found in these plants remain unexplained. The high damage on cowpeas could also be attributed to larvae which typically develop inside the dried cowpeas thus the high initial damage of 13%. Repellence may not work if resident insect pest infestation is already high. *C. imberbe* ash was as effective as ASD over 16 weeks in suppressing or reducing cowpea insect pest numbers and was more effective than the other plant powder-based treatments.

On maize, *L. javanica* at application rates of 2% and 5% were the most effective as there was no significant difference between the two treatment levels. The mean numbers of insects in the control were lower than in treatments of *S. africana* as insects were being attracted to the pesticidal plants. The lower mean number of live insects in the control than in *S. africana* treatment could have been as a result of the pesticidal plants attracting grain storage pests. In the *L. javanica* treatments, there were lower insects which compared well to studies by Mwangi *et al*. (1992) which showed that essential oils of *L. javanica* have promising repellent properties on maize weevils.

The results showed that plant materials are effective over a short storage period of 24 weeks or less. ASD was the most effective in reducing grain damage over the whole storage period. The least effective plant material in preventing grain damage was found to be *S. africana*. The study revealed that, plant materials are effective over a short period of time both in maize and cowpeas. Since the plant materials are suitable for short term storage, reapplication at a 16 week interval is recommended subject to availability of plant materials. Residual properties of the plant materials need to be tested so as to get the exact time over which the plant materials will be effective and this will help in avoiding unnecessary applications. Emerging evidence suggest that active ingredients in some pesticidal plants' efficacy vary depending on time of year harvested and geographical location (P. C. Stevenson, Natural Resources Institute, University of Greenwich, *pers comm*). The mode of action of the plant materials also need further investigation to ensure the pant materials are correctly and effectively used.

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