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Smallholder farmers' indigenous knowledge of maize storage pests and pesticidal plant use: The case of Wards 9 and 10 in Bikita District, Masvingo Province, Zimbabwe

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Farmers' indigenous knowledge of storage insect pests and management practices in stored grain protection against insect pests are critical for sustainable food security in the smallholder sector in Zimbabwe. A survey was conducted among 48 and 51 maize farmers in wards 9 and 10 Bikita district respectively, to evaluate their knowledge, attitudes and traditional maize storage management practices against storage insect pests. The selected farmers grew maize and a variety of vegetables for subsistence. Problem storage pests listed in order of prevalence were maize weevil (*Sitophilus zeamais*) 49%, lesser grain borer (*Rhizopertha dominica*) and maize weevil (*Sitophilus zeamais*) complex 25.5%, lesser grain borer (*Rhizopertha dominica*) 17.7% and larger grain borer (*Prostephanus truncatus)* 7.3%. The commonly used botanical pesticides in the two wards were gumtree (*Eucalyptus* spp) (24.6%), tamboti (*Spirostachys africana*) (7.2%), lilac tree (*Melia azedarach)* (4.1%), sunflower (*Helianthus annuus)* ash (5.1%), cow dung (3.1%), lemon bush (*Lippia javanica)* (2%), murwiti (*Rapanea melanophloeos*) (1%), sweet basil (*Ocimum basilicum*) (1%) and finger millet (*Eleucine coracana*) chuff (1%),wood ash (4.1%) and mixtures of the above mentioned botanicals (4.5%). The botanicals are mixed with maize grain before storage either in sealed hessian bags or as loose grain placed in the granary plastered with cow dung. The use of botanicals was more prevalent in Ward 10 (100%) than ward 9 (14.7%). Farmers resort to the use of cheap and locally available botanicals when there is no money to buy synthetic insecticides. There is an urgent need for laboratory evaluation of the efficacy, chemical composition and mode of action in order to come up with dosage guidelines of these ethnobotanicals for the resource poor smallholder farmers.

Key words: Indigenous knowledge, ethnoecological knowledge, ethnobotanicals, *Sitophilus zeamais, Rhizopertha dominica, Prostephanus truncatus,* synthetic insecticides, smallholder farmers.

INTRODUCTION

Maize (*Zea mays* L.) is one of the most important grains in the world and it is commonly stored to provide food reserves and also seed materials for planting (Boxal, 2002). Maize is not only important for human consumption, but also for animal feed as well as material for the manufacture of various industrial products. In Zimbabwe, maize is the main staple food crop. Maize is mainly grown in Zimbabwe under different weather conditions in almost all the agro-ecological zones. In Zimbabwe, communal, A1, A2 and commercial farmers usually plant maize during summer time usually from October to January when there is an adequate amount of precipitation. In a normal year harvesting is done around April/May and will be stored until the next harvest.

Despite high maize production, large amounts of maize stored is lost to storage pest attack after harvesting especially among smallholders farmers (Muzemu et al., 2013). This leads to loss of both maize grain quality and quantity and may also reduce future maize production for those who retain grain as seed (Iloba and Ekrakene, 2006). Maize storage insect pests cause serious damage on maize if it is not protected and this affects food security in particular and the economy in general (FAO, 1991). This often affects smallholder farmers or people in rural areas who cannot afford to buy synthetic pesticides to protect their stored maize from insect pest attack as pesticides are expensive (Muzemu et al., 2013). Industrial pesticides are not only expensive for the resource poor communal farmer but also pose health hazards to both producers and consumers and the ecosystem where the pests develop resistance to the chemicals (Dent, 2000).

In Zimbabwe, communal farmers face problems in protecting their harvested grain crops from insect pest attack during storage. Alarming storage grain loses of up to 50% in cereals have been reported although the average loses stand at around 20% in the warm climate of tropical Africa (Nukenine, 2010; Derera et al., 2001; Dhliwayo and Pixley, 2003). Grain storage is a way or process by which grain is kept for future use. Food grain needs to be stored from one harvest to the next in order to maintain its constant supply throughout the year and to preserve its quality and quantity until required for consumption. For communal farmers in Zimbabwe, the main purpose of storage is to ensure household food supplies and seed for the next planting. Maize is the staple food for Zimbabwe and its production is seasonal hence the need to store supplies to last the whole year. In Zimbabwe, the maize storage grain insect pest complex is dominated by maize weevil *Sitophilus zeamais* (Motschulsky) and larger grain borer *Prostephanus truncatus* (Horn) (Dhliwayo and Prixley, 2003; Mvumi et al., 2003).

The storage grain insect pest management strategies of these resource poor communal farmers is characterised by a diversity of practices where farmers manipulate and derive advantages from local resources and natural processes. These indigenous knowledge systems or technologies are important and are being used in modern day agriculture by the farming communities from which they emanate from (Mapara and Mazuru, 2015). Indigenous Knowledge is defined by Chapungu and Sibanda (2015) as that knowledge accumulated over generations of living in a particular environment or locality and has been vital in responding to environmental challenges, including floods, diseases and pest infestations and their attendant effects. Indigenous knowledge is local knowledge which is unique to a given culture or society (Warren, 1991), and it contrasts with international knowledge system generated by universities, research institutions and private firms (Chapungu and Sibanda, 2015). According to UNESCO, indigenous knowledge is passed from generation to generation, usually by word of mouth and cultural rituals, and has been the basis for agriculture, food preparation, health care, education, conservation and the wide range of other activities that sustain societies in many parts of the world.

Indigenous knowledge systems is also known by various terms which include traditional knowledge, ethno science, cultural experiences and ethno-based knowledge systems (Dirwai, 2007). According to Dhlamini et al. (2015), indigenous knowledge has various merits which include the fact that it is a cost effective and sustainable mechanism for poverty alleviation and is locally manageable, locally meaningful, ecologically sound and socially acceptable. In addition they argue that indigenous knowledge is easy to acquire as it relies on locally available skills and material that are often more cost effective than introducing exotic technologies since what is needed for immediate survival is taken from the immediate environment.

Many researchers have reported that farming communities possess low cost traditional knowledge systems of controlling grain storage insect pests which include the use of traditional botanical pesticides or ethno botanicals (Dales, 1996; Ogendo, 2000; Chikukura et al., 2011; Nukenine, 2010; Sola et al., 2014). Knowledge of ethno botanicals as grain protectants is likely to be accompanied by an equal informed knowledge of how storage pests can be controlled in a sustainable manner for food and nutritional security as an alternative to the use of synthetic insecticides which are expensive to the poor farmers and not ecofriendly. The strength of farmers' knowledge is that it is the product of frequent observation of grain and insect grain pests during several storage seasons.

Naturally, botanical insecticides are believed to possess

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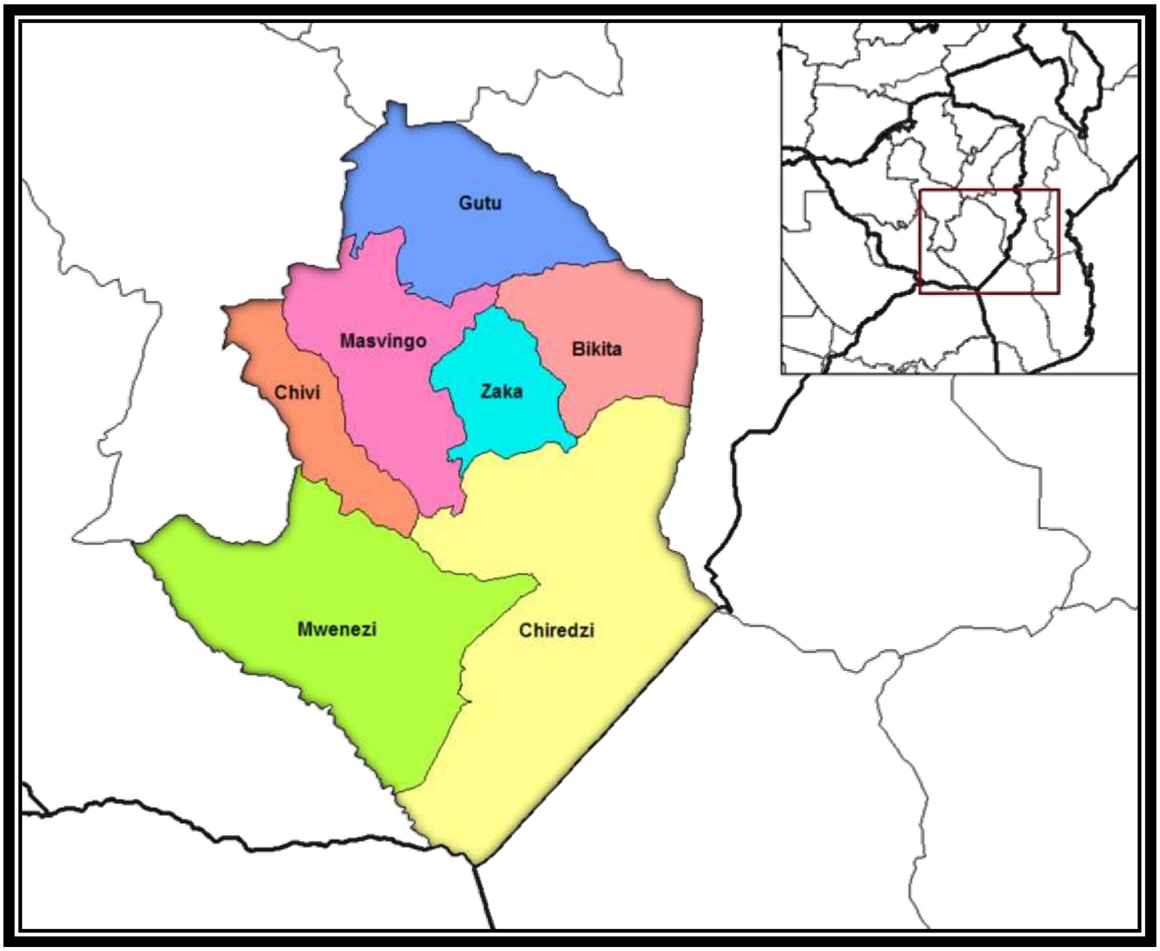

Figure 1. Location of Bikita district in Masvingo Province, Zimbabwe. (Source: Google map).

certain attributes which put them at a higher advantage over conventional insecticides. These include low mammalian toxicity, less persistence in the environment, selectivity towards target pests and nonphytotoxicity (Isman, 2006). These have led to the belief that plant derived insecticides are safer than synthetic products. The documentation and validation of this knowledge is especially useful for various reasons which include to set research agenda, for developing extension messages, planning, and campaign strategies and form the basis for constructive collaboration between researchers and farmers in Masvingo province. Therefore, the objectives of this survey were to:

i) Identify problem maize storage insect pests in two wards in Bikita District for resource poor smallholder farmers.
ii) Identify the various indigenous methods of maize storage insect pest control in Bikita District including use of pesticidal plants by resource poor smallholder farmers.
iii) Identify common post harvest grain storage structures in Bikita District.

MATERIALS AND METHODS

Study areas

The study was conducted in two maize growing wards of Bikita District, namely Ward 9, Mapfuwa village and Ward 10, Bhunu village. These two wards lie largely in natural region III where climatic conditions allow for maize production. Bikita is a district in the Masvingo Province of Zimbabwe (Figure 1). It is located about 80 km east of Masvingo town and its name is probably derived from the Shona word *Dikita* which means *antbear*, which describes the shape of a nearby hill. The district used to be known as Denga which means *up in the clouds.* It is a mountainous region characterized by very steep slopes with sandy-loamy soils. It is the third driest district after Chivi and Chiredzi in Masvingo province. It covers an area of approximately 10,000 km², and has a population of around 200,000 people (Mushore et al., 2013). About 81% of the district is classified as belonging to the natural regions (IV and V) with mean annual rainfall ranging from 400 to 700 mm. Agriculture is the major livelihood activity in the area with maize being the dominant crop grown (Mushore 2013).

Data collection and analysis

Data was collected using a household survey conducted in August

Table 1. Percentage of respondents according to sex, age, education, source of income and maize farming experience in ward 9 and 10 of Bikita district.

Variable	Category	Ward 9 (n= 48)	Ward 10 (n= 51)
Gender	Female	70.8	58.5
	Male	29.2	41.5
Age	Young (<30 years)	16.7	7.5
	Middle (30-50 years)	29.2	43.4
	Old (> 50 years)	54.1	49.1
Education	None	4.1	0
	Primary (Up to Grade 7)	54.2	56.6
	Secondary (Up to Form 4)	37.5	43.4
	Tertiary (College)	4.2	0
Income	Farming only	39.6	
	Farming + Remittances	22.9	
	Farming + Formal employment	4.2	94.3
	Farming + Pension	4.2	5.7
	Farming + Piecework	16.7	
	Farming + Beer brewing	6.2	
	Farming + Vending	6.2	
Maize farming experience	Short (< 10 years)	8.3	60.4
	Long (> 10 years)	91.7	39.6

and September 2015. Semi-structured questionnaires were employed in interviews of randomly selected farmers. A total of 48 and 51 farmers were interviewed in wards 9 and 10 respectively. The respondents were selected with the help of village leaders and Agricultural Technical and Extension (AGRITEX) officers on the grounds that they grow maize among other crops. The questionnaire was designed in English and translated into Shona, which is understood by all the farmers and pretested using small samples of farmers in the same areas before using it in this study.

The data collected included the biodata such as sex, age, district, village, ward, educational background, major source(s) of income from the farm and other sources, crops grown and production per season, duration in farming, maize storage pests, maize storage structures, synthetic maize storage pesticides used and source, ethno-botanical maize storage pesticides used and source and ethno-botanical formulations. Data were recorded between August and September 2015 by the area AGRITEX officers. Statements made on open ended questions that were not coded were also used to substantiate the numerical data.

RESULTS

Characteristics of respondents

The majority of the respondents (64.7%) were females older than thirty years in both wards and had undergone formal education, primary 55.4%, secondary 40.5%, college 2% and only 2% never went to school (Table 1). The major source of household income in both wards was farming supplemented in some households by remittances, vending, pensions, piece work, beer brewing and even formal employment (Table 1). The major crops grown in fields and home gardens in both wards are maize, rapoko, beans, cowpeas and a variety of vegetables. Most farmers (65.7%) were experienced farmers with more than ten years of growing maize (Table 1).

Major grain storage pests

The major maize storage pests were maize weevils (*S. zeamais*) 52.1% reported in ward 9 and 46% in ward 10, lesser grain borer (*R. dominica*), 33.3% in ward 9 and 4% in ward 10, larger grain borer (*P. truncatus*), 14.6% in ward 9 and non reported in ward 10 (Table 2).

Maize storage structures

Only 10% of farmers in ward 9 store their grain in specialized grain storage structures or granaries. Most farmers (90%) in ward 9 and all farmers in ward 10 store their grain in living quarters in sealed 50 or 90 kg hessian bags (Table 3). The living quarters are either made of wooden poles with dagger or brick walls with either thatch

Table 2. Percentage of respondents who reported storage insect pests and common ethnobotanicals used.

Variable	Category	Ward 9 (n= 48)	Ward 10 (n= 51)
Storage insect pest	Maize weevil only	52.1	47
	Maize weevil + Lesser GB	0	51
	Larger grain borer only	14.6	0
	Lesser grain borer only	33.3	2
Ethnobotanicals used	Tamboti (Mutovhoti)	0	14.3
	Lilac tree (Musiringa)	0	8.2
	Lemon bush (Zumbani)	2.1	2
	Cape beech (Murwiti)	0	2
	Gum tree (Mugamu)	6.3	42.9
	Sunflower (Maringazuva)	0	10.2
	Sweet basil (Manhuwe)	0	2
	Ash (Madota)	2.1	6.1
	Dung (Ndove)	2.1	4.1
	Finger millet chuff	0	2
	Tamboti + Sunflower	0	2
	Dung + woodash	0	2
	Gumtree + sunflower ash	0	2
	Gumtree + Lemon bush	2.1	0
	None of the above	85.3	0

Table 3. Percentage storage facilities used by smallholder farmers for maize grain storage.

Storage facility	Ward 9 (N=48)	Ward 10 (N=51)
Ordinary room - bag storage	87.5	84.9
Granaries - pole and plastered with anthill soil; some not plastered	10.5	15.1
Granaries- brick and plastered with mortar	0	0
Bin/drum	2	0
Hermetic bags	0	0
Other	0	0
Total	100	100

Source: This study

grass, iron sheets or asbestos as roofing material.

Crop production patterns

Maize, field beans, cow peas, rapoko, groundnuts, roundnuts, sunflowers and a variety of vegetables were the most commonly grown crops. In ward 9, maize and vegetables were grown by all respondents (100%), cowpeas 60%, rapoko (25%) and field beans 16.7%. In ward 10 the scenario was similar to ward 9 for maize and vegetables. Unlike ward 9, farmers in ward 10 grew groundnuts (17%), mbambara roundnuts (17%) and sunflowers (1.9%). Cereal and legume crops are grown in arable fields while vegetables which include covo, rape, cabbage, tomatoes, onions and curcurbits are grown in home gardens. The cereal and legume crops are grown under rain fed conditions in summer while vegetables are grown all year round where irrigation water is available.

Farmers' knowledge of maize storage pests and control practices

All the respondents in both wards experienced post-harvest grain damage by storage insect pests. According to the survey, the major maize grain storage insect pests are the maize weevil (*S. zeamais*), lesser grain borer (*R. dominica*) and larger grain borer (*P. truncatus*) (Table 2).

In ward 9, 52.1% of the farmers experienced grain

Table 4. Insecticidal dusts currently available in Zimbabwe for admixture to grain.

Trade name	Active ingredient (% are weight for weight)
Hurudza Grain	fenitrothion 1.7% + deltamethrin 0.05%
Shumba Super	fenitrothion 1.0% + deltamethrin 0.13%
Actellic Super Chirindamatura	pirimiphos-methyl 1.6% + permethrin 0.3%
Chikwapuro	pirimiphos-methyl 2.5% + deltamethrin 0.1%
Ngwena Yedura	pirimiphos-methyl 2.5% + deltamethrin 0.2%
Actellic Super Gold Dust	pirimiphos-methyl 1.6% + thiamethoxam 3.6%
Nhovo	malathion 1% dust

Source: This study.

Table 5. Pesticidal plants commonly used in Bikita and how they are used to control maize grain insect pests.

Common name	Vernacular name	Botanical name	How it is used
Sweet basil	Manhuwe	*Ocimum basilicum*	Mix leaves and branches with grain in bag
Lilac tree	Musiringa	*Melia azedarach*	Mix leaves and small branches mixed with grain in bags
Tamboti	Mutovhoti	*Spirostachys africana*	Stem and branches cut into small pieces and place at the bottom, middle and top of the grain in storage bag and seal
Cape beech	Murwiti	*Rapanea melanophloeos*	Mix leaves with branches with grain in the bag
Gum tree	Mugamu	*Eucalyptus* spp	Mix squeezed fresh leaves with grain in the bag
Sunflower	Maringazuva	*Helianthus annuus*	Burn sunflower stem and collect ash and mix it with grain in bag
Finger millet chuff	Hundi yerukweza	*Eleucine coracana*	Mix chuff with grain in bag
Cow dung	Ndove		Plaster granary floor and walls with cow dung and store grain in bags or unbagged/loose grain
Wood ash	Madota		
Lemon bush	Zumbani	*Lippia javanica*	Mix small branches with leaves with grain in sealed bags

Source: This study.

damage due to maize weevil (*S. zeamais*) and 33.3% of the farmers reported damage and loss due to lesser grain borer (*R. dominica*) and 14.6% damage by larger grain borer (*P. truncatus*) were recorded. On the other hand, in ward 10, the incidence of maize weevil only was 47%, with 51% cases of damage by a pest complex of lesser grain borer (*R. dominica*) plus maize weevil (*S. zeamais*) and only 2% damage and loss due to lesser grain borer (*R. dominica*) only. No reports of larger grain borer (*P. truncatus*) were reported in ward 10. The farmers reported that the pests affect maize grain both qualitatively and quantitatively. The market price of the grain is also greatly reduced after attack by insect pests. The insect pests damage the grain by boring holes and producing frass and flour dust. The storage pests attack the grain soon after harvest and throughout the storage period in winter, spring and summer.

All respondents in both wards reported the use of synthetic pesticides to protect their grain in storage. However the pesticides are only used when the cash to buy them is available. The use of synthetic pesticides alone was more prevalent in Ward 9 than ward 10 where both synthetic pesticides and botanical pesticides were used. The commonly used synthetic pesticides are Actellic Super Gold Dust, Actellic Super Chirindamatura, Shumba Super, Hurudza Grain, Chikwapuro, Ngwena Yedura and Nhovo (Table 4). When the cash to buy effective synthetic pesticides is not available, as is always the case in rural areas, the farmers have reported that they resort to using ethno-botanicals and other locally available options like cow dung and wood ash.

All the respondents in ward 10 have at one time or the other used botanicals to protect their stored grain, whilst only 14.7% of the farmers in ward 9 have used botanicals in grain protection. The respondents reported seven different pesticidal plants and three other plant based products. The commonly used pesticidal plants were tamboti (S. africana), Lilac tree (M. azadarach), Lemon bush (L. javanica), Cape beech (R. melanophloeos), gumtree (Eucalyptus spp), sunflower (H. annuus) and

sweet basil (O. basilicum). The local names of the pesticidal plants are given in Table 5. Other traditional plant based grain protection options mentioned were wood ash, cow dung and finger millet (E. coracana) chuff (Table 5).

Amongst the pesticidal plant options for maize grain protection in storage, the gum tree (*Eucalyptus* spp) leaves are the most popular with 42.9% of farmers having used them in ward 10 and 6.3% in ward 9. The least popular option for maize grain protection is finger millet chuff in ward 10 with only 1.9% whilst Lilac tree (*M. azadarach*), sweet basil (*O. basilicum*) and finger millet (*E. coracana*) chuff were not reported in ward 9.

For botanicals, plant parts such as leaves, branches and stems are mixed with grain in sealed bags (Table 5). As for sunflower (*H. annuus*)) the farmers reported that they burn the stems and the resultant ash is mixed with grain and then bagged and sealed. With finger millet ((*E. coracana*)) the farmers roast and pound finger millet grain to remove chuff. The chuff is then mixed with grain before bagging and sealing. Cow dung is used to plaster the interior walls of granaries and the grain is either stored as loose grain or bagged. No specific dosages (quantity per unit mass of grain?) were given by the respondents for the various options.

DISCUSSION

According to the farmers, the major maize storage pests in Bikita are maize weevil (*S. zeamais*), lesser grain borer (*R. dominica*) and larger grain borer (*P. truncatus*). This is consistent with literature from other parts of Zimbabwe (Dhliwayo and Prixley 2003; Mvumi et al., 2003) and southern Africa (Kamanula et al., 2011). *S. zeamais* has been reported to be a common maize storage pest since time immemorial (Derera, et al., 2001) and *P. truncatus* is relatively new in Zimbabwe having been reported in several parts of Zimbabwe mostly during the 2006/2007 season (Nyagwaya, 2009). In this study, the number of farmers who reported the presence of *P. truncatus* was the lowest which seems to suggest that it is still becoming established as a newly introduced pest. The LGB is a serious pest of farm stored maize and dried cassava and can cause up to 40% loss in maize and up to 80% in dried cassava over a period of six months in storage (Golob, 1988). The recent introduction and spread of *P. truncatus* into Zimbabwe has increased maize grain storage problems both on the cob and loose grains.

The study has revealed that there are various traditional methods of controlling maize storage pests. Various researchers have reported the efficacy of a number of pesticidal plants (botanicals) against maize storage pests (Muzemu et al., 2013; Mandudzi and Edziwa, 2016; Chikukura et al., 2011; Kamanula, 2011; Masundire, 2015). Botanicals are toxins and/ or deterrents that are derived or extracted from plants or plant parts. Many botanical insecticides have been known and used since time immemorial but were displaced from the marketplace by synthetic insecticides in the 1950s. This study revealed the use of mainly fresh leaves and stems as fumigants of various botanical pesticides including mutovhoti (*S. africana*), musiringa (*M. azedarach*), zumbani (*L. javanica*), murwiti (*R. melanophloeos*), gumtree (*Eucalyptus spp*), sunflower (*H. annuus*) and sweet basil (*Ocimum basilicum*). The farmers reported that they mix the maize grain with fresh leaves and branches in sealed hessian bags. However, research has shown that the powders and oil extracts are more effective as grain protectants for some of the botanicals. For example, Masundire et al (2015) recommended that *E. grandis* can be used as a natural pesticide in maize storage when it is air dried and ground into powder and admixed with grain at 5 g/kg as a single application at the beginning of the storage season. As a powder, *E. grandis* protection can be guaranteed for at least six months (Masundire et al., 2015). Mandudzi and Edziwa (2016) recommended that *E. tereticornis* leaf powder be used as a pesticide against *S. zeamais* in stored grain and that regular application of the powder was necessary as the efficacy of the powder gets low with time. Various other researchers have also recommended the use of air dried powdered plant parts as superior grain protectants as compared to fresh leaves and other plant parts (Fekadu et al., 2012; Parwada et al., 2012; Islam and Talukder, 2005). Parwada et al. (2012) suggest that the powders act by dehydrating and suffocating the weevils and also by restricting weevil movement.

Wood ash has been used since time immemorial as a botanical pesticide against maize storage insect pests. Various researchers have demonstrated that wood ash if mixed with grain in sufficient quantities of 20% or more w/w can effectively protect grain against insect attack (Golob, et al., 1982; Gemu et al., 2013; Archiano et al., 1999; Gadzirayi et al., 2006). In Zimbabwe other sources of ashes are from maize cores, mopane tree, *Colophospermum mopane,* cattle and goat droppings and from the lead wood, *Combretum imberbe*. The ash is either mixed thoroughly with the grain or added to the stored product in various layers. The ash dust is believed to act by inhibiting insect behavior, affecting movement and reproduction by blocking air and space between grains (Gemu et al., 2013) suggesting the need for higher doses in order to submerge the grain. In addition, the abrasive nature of the ashes may desiccate the pests. The use of wood ash, however is only viable for small holder farmers particularly for the preservation of small quantities of seed grains, because of excessive quantities of dust required.

Sweet basil, *O. basilicum* has been reported by Grainge and Ahmed, 1988 as having leaves and seeds rich in pesticidal oils which are repellent, toxic or growth inhibitory to many insect pests.

The insecticidal compounds in wild *Oceium spp* have been identified as eugenol (Chogo and Crank, 1981) and linalool, a terpenoid (Weaver et al., 1991).

L. javanica has been reported to have medicinal (Viljoen et al*.,* 2005), acaricidal (Madzimure et al., 2011) and insecticidal (Chikukura et al., 2011) properties. Medicinally it is taken as a tea to relieve headache, flu and cold. It is used to kill ticks in livestock and as an insecticide against grain storage pests. The insecticidal chemicals are oils such as perillyl alcohol, cis-verbenol, ciscarveol, geraniol, citronellal, perillaldehyde and caryophyllene oxide. Oils are thought to affect target pests in various ways including suffocation due to blocked spiracles, preventing gas exchange in egg membranes, and the fatty acids in oils may disrupt cell membranes thereby disrupting normal metabolism (Buss and Park-Brown, 2009).

S. Africana is traditionally a medicinal pain killer for toothache and is reported not to be very effective as a storage pesticide (Chikukura et al., 2011). Dirwai (2007) has documented its cultural role in conserving flora and fauna in the environment in Zimbabwe. The use of finger millet chaff as a grain protectant however is not well documented.

However respondents reported the use of synthetic chemical pesticides is still the preferred option when funds permit. This observation is in agreement with various literature (Mvumi and Stathers, 2003; Chikukura et al*,* 2011). While synthetic pesticides have been credited for their efficacy as compared to botanicals, they are increasingly receiving negative publicity due to high cost, health and environmental risks (Kamanula et al., 2011). The indiscriminate use of chemical pesticides to protect grain could lead to the increase in the risk of contamination of the home environment, pesticide residues in meals thereby increasing health risks to consumers. This highlights the importance of identifying and promoting safer and low cost locally available alternatives to the synthetic products such as pesticidal plants.

Kamanula, et al*.* (2011), argues that although effectiveness of botanicals may be unfavourable as compared to synthetic pesticides, even moderate efficacy is of great importance to resource poor farmers since alternative to their use may be crop loss and food shortage.

Conclusion

The study provides valuable firsthand information on the maize storage grain insect pest complex and the commonly used pesticides, both synthetic and botanical in Bikita district. Problem maize storage insect pests in Bikita are *S. zeamais*, *R. dominica* and *P. truncatus* which are generally the same pests common in many parts of Zimbabwe. Synthetic pesticides are expensive for most resource poor farmers and are associated with health risks for the farmer as opposed to botanicals which are safer, cheaper and locally available. In addition, the botanicals have medicinal and ritual properties for example lemon bush (*L. javanica*) in Zimbabwe. The efficacy of the botanicals can be greatly improved if farmers in Bikita use powders of plant parts rather than fresh plant parts since research has revealed that powders are more efficacious than whole parts. Also regular applications of the powders may be necessary as the efficacy of most botanical powders diminishes with time. However there is still a lot of research to be done both in the laboratory and on farm to evaluate formulations, dosages, active biomolecules, modes of action and frequency of application for the identified ethnobotanicals. Also efforts to find simple agronomic ways of propagating, growing and even conserving some of these botanical plants should be promoted.

Credible or novel scientific information about the botanicals has the potential to empower farmers in Bikita and in deed in Zimbabwe to influence decision making in sustainable grain protection and food and nutritional security. Embracing traditional approaches in grain protection is a strategic mechanism in supporting sustainable development as enshrined in the UN sustainable development goals 2030.

Conflict of Interests

The authors have not declared any conflict of interests.

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