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Full Length Research Paper

Insecticidal Properties of Garlic (*Allium sativum)* Aqueous Extracts on Beans (Phaseolus valgaris) and Maize (Zea mays) Pest

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The study is aimed at examining the insecticidal properties of aqueous extracts of garlic at different concentration (10, 20, 30, 40 and 50 mg). The grains were kept open for infestation. The results showed a very high effectiveness of different concentrations of garlic aqueous extract on post-harvest pest of Beans (Callosobruchus maculutus) and Maize (Sitophilus zeamais). S.zeamais recorded mortality total rate of 49(98%) when compared to the C.Maculutus which had 43(86%). Increase in the concentration of the garlic aqueous extract also showed an increase in mortality of both post-harvest pests tested. In the Analysis of Variance (ANOVA), the F-distribution calculated which was 0.195 for the mortality of both post-harvest pests is less than that which was tabulated at (4.84), this implies that there was a relationship between the extracts and mortality of Sitophilus zeamais and Callosobruchus maculutus.

Keywords: Aqueous extracts, biological pest control, garlic

INTRODUCTION

On a global scale, beans are the most important legume staple for human consumption (Lopez-Pedrous *et al*., 2012). They belong to taxonomic hierarchy: Order: *Fabales*, Family: *Fabaceae* with several varieties. In Nigeria, a number of beans and beans varieties are cultivated. These include varieties of the Common beans (*Phaseolus vulgaris*); African yam bean (*Sphenostylis stenocarpa*); Mung beans (*Vignaradiata*); Soybeans (*Glycine max*); Pigeon pea (*Cajanus cajan*); African oil bean (*Pentaclethra macrophylla*) and the black eyed pea (Cowpea) (*Vigna unguiculata*) (Popoola, 2011). Beans are a rich source of essential nutrients in human diet, providing proteins, complex carbohydrates, vitamins, mineral elements, dietary fibres and complex carbohydrates, while being low in fats, sodium and cholesterol-free (Gepts *et al*., 2008). Their high protein content makes them relatively cheap alternative protein source compared to the highly priced animal or meat-protein sources for households in developing countries (Lopez-Pedrous *et al*., 2012). At present a number of these bean seeds are processed into flours and utilized as food or feed (Fasakin *et al*., 2005; Lopez-Pedrous *et al*., 2012). Their uses include, the fortification of indigenous starchy meals as composites (Okpala *et al*., 2013; Yusufu *et al*., 2013; Aderonke *et al*., 2014); production of flavouring fermented food condiments used in the preparation of traditional dishes (Achi, 2005); beverage (soy-milk) and cake (soy-cake, tofu) (Onuorah *et al*., 2007; Obadina *et al*., 2013).

Stored beans suffer heavy losses in terms of both quality and quantity, and these losses are caused mostly by bean bruchids (Coleoptera: Bruchidae), although other pests such as the flour mite, *Acarussiro* (Acari: Acaridae), may be important in some African countries. Beans in Africa fall under attack by half a dozen species of bruchids: the bean bruchid or common bean weevil, *Acunthoscelides obtectus;* the cowpea bruchids *Callosobruchus chinensis* and *Callosobruchus maculutus;* the Rhodesian bean weevil, *Callosobruchus rhodesiunus;* the Mexican bean weevil or spotted bean weevil, *Zabrotes subfasciutus;* and unidentified species of *Bruchidius.*

Maize (*Zea mays* L.) is the second most cultivated crop in Nigeria in terms of area harvested (5.8million Ha, second to Cassava's 7.1 million Ha). Nigeria is the second largest maize producer in Africa, after South Africa, with an estimated 10.79 million MT produced in 2014 (FAOSTAT, 2014a). The largest volumes of maize are produced in the Northern region, particularly in Kaduna, Borno, Niger, and Taraba and in the South-Western states including in Ogun, Ondo and Oyo. Despite its high production volumes, Nigeria's average maize yield of 1.8 MT/Ha (FAO, 2014b) is one of the lowest among the top 10 maize producers in Africa. It lags behind countries such as Egypt and South Africa where the yields are 7.7MT/Ha and 5.3MT/Ha respectively (FAO, 2014b). Simply by addressing this low yield issue, Nigeria could become the largest maize producer in Africa and one of the largest producers in the world without increasing the area currently used for its cultivation. Maize has become indispensable for food security in Nigeria. Much of the maize produced is consumed in a range of commercial sectors. About 50% of the maize produced is consumed by the animal feed sector, with poultry claiming as much as 98% of the total feed produced in Nigeria between 2005 and 2010 (USDA report, 2005-2010). Maize is very rich in micronutrients such as zinc, iron and vitamin A. Due to the importance of maize in the Nigerian diet, a large portion is use as household food in different such as; local corn porridge (*Pap*), traditional corn meal (*Tuwo*), boiled or roasted corn.

Maize losses due to pests and diseases, both pre- and postharvest, far outweigh any reasonable hope for increases in productivity through improved germplasm and pre-harvest management (Chabi-Olaye *et al*., 2005). The most damaging maize pests in SSA are lepidopterous stem and cob borers, post-harvest weevils and the larger grain borer. The maize weevil (*Sitophilus zeamais)* Motsch (Coleoptera: Curculionidae) is a serious pest of stored maize, causing qualitative and quantitative losses. Losses as high as 36% have been recorded on stored maize in Benin, due principally to infestation with *Prostephanus truncatus* (Horn) (Coleoptera: Bostrichidae) (Lamboni and Hell, 2009). These losses have an impact on food security and income generation and contribute to high food prices by removing part of the supply from the market (Abebe *et al*., 2009; Yuya *et al*., 2009).

Insects have evolved a variety of physiological and behavioural responses to various toxins in natural and managed systems. These varied responses can reflect the toxin's mode of action and the extent to which it influences pest behaviour. Insects may withstand insecticide applications either through the evolution of physiological mechanisms allowing them to cope with high insecticide levels on or within the body, or through behavioural mechanisms minimizing their exposure to insecticides (Hoy, 2005). Climatic conditions in the tropics favour the cultivation of numerous food crops but also favour the development and proliferation of storage pests and fungal diseases, which can cause considerable damage in storage and constitute an obstacle to processing (Sousa *et al*., 2009; Jahromi *et al*., 2012). Stored-product pests are particularly important because they attack the final agricultural product. Plant insecticides have played an important role in the traditional methods of protection against grain pests and disease (Stancic *et al*., 2011; Jahromi *et al*., 2012).This research will try to see the efficacy of *Allium sativum* (Garlic) aqueous extract as insecticide of maize and beans pests.

The contributions of agriculture to national growth and development could not be under estimated. Nigerian agricultural sector contributes between 30-42% and employs 65% of the labour force and has been describe as the most important sector of the economy which holds a lot of potentials for the future economic development (Emeka, 2007). It has been estimated that between 20-40% of global productivity are lost as a result of direct yield losses caused by pests and pathogen (Oerke *et al*., 2004). These losses have an impact on food security and income generation and contribute to high food prices by removing part of the supply from the market (Abebe *et al*., 2009; Yuya *et al*., 2009). Cereals such as maize, wheat and rice, together comprise at least 75% of the world grain production and they are among the world's most important staple foods (FAO, 2008). And beans also on a global scale, is the most important legume staple for human consumption (López-Pedrouso *et al*., 2012). So this research will seek provide a solution for to the pests of beans and maize. This research seeks to examine the insecticidal properties of the total aqueous extracts of garlic on beans and maize pest. Specific objectives;

(a) To determine the control effectiveness of *Allium sativum* aqueous extract.
(b) To determine the mortality rate effectiveness of *Allium sativum* aqueous extract.

Storage pests of maize

Insect pests are the principal cause of grain losses in the field and storage (Suleiman *et al*., 2013). In general, smallholder farmers stored maize for three main purposes: as food until next season; as seed and for selling when prices become available. However, storage pest damage significant portions of their stored maize (Rugumamu, 2004). The most serious insect pests that cause severe economic damage to maize in the storage are the maize weevils (*Sitophilus zeamais)* and the larger grain borer (LGB), *Prostephanus truncatus* (Suleiman *et al*., 2015). Others important storage insect pests include the angoumois grain moth (*Sitotroga cerealella*), the lesser grain weevil (*Sitophilus oryzae*), Red flour beetle and dried bean beetle (Gitonga *et al*., 2015). Post-harvest loss reduction has received attention in many policy documents across nations to ensure global food security, particularly in developing countries (Ansah and Tatteh, 2016). On the account of post-harvest losses, about 30% to 40% of agricultural produce is not reaching the consumer (Adejo, 2017). Ahmed, (2013) reported that post-harvest losses are making Nigeria farmers poorer. Patrick, (2013) reported that Nigeria records over 40 percent post-harvest losses, which has led to an unprecedented hike in food importation in the country.

Maize weevil (*Sitophilus zeamais*)

The maize weevil *Sitophilus zeamais* Motschulsky, is a small reddish-brown to black snout beetle (Suleiman and Abdulkarim, 2014). It is described as one of the most destructive stored and primary grain pests of maize and grain in tropical and subtropical regions (Suleiman *et al*., 2015). *Sitophilus Zeamais* is so devastating and capable of multiplying to large populations, causing tremendous damage to the stored grain (Cosmas *et al*., 2012). It has been estimated that 5-30 % of the total grain weight of the stored product is lost due to infection by *Sitophilus Zeamais* (Ojo and Omoloye, 2012). Other studies cite as high as 80 % loss may occur in untreated maize grain stored in traditional structures (Tefera *et al*., 2011). Infestation by *S. Zeamais* often begins in the field, but serious damage is done in storage (Fikremariam *et al*., 2009; Suleiman *et al*., 2015).

Life cycle of *S. zeamais*

*Sitophilus zeamais*is regarded as internal feeders of grains; with typically range from 2.5- 4.5 mm in length (Kasozi, 2013). The average life span of *S. Zeamais* ranging from 3 to 6 months up to one year (Rees, 2004). Female weevil release sex pheromones to attract the males (Mason, 2003). Once fertilized the female uses the snout to excavate a small hole in a maize kernel and laying eggs (ovipositing) and plugs the hole with a waxy secretion (Kasozi, 2013). At optimal conditions, each female can lay up to 150 eggs in her lifetime (Gewinner *et al*., 1996).

The Eggs hatch into small larvae in about 6 days; the larva feed and develops inside the maize kernels for about 25 days (Kasozi, 2013). Total development periods on environmental conditions but normal range from 35 to 110 days (Kossou and Bosque-perez, 1998). The adults emerge by eating their way towards the testa causing rugged exit holes resulting in a damaged kernel and reduced grain weight (Mwangangi and Mutisya, 2013; Suleiman *et al*., 2015) (Figure 1).

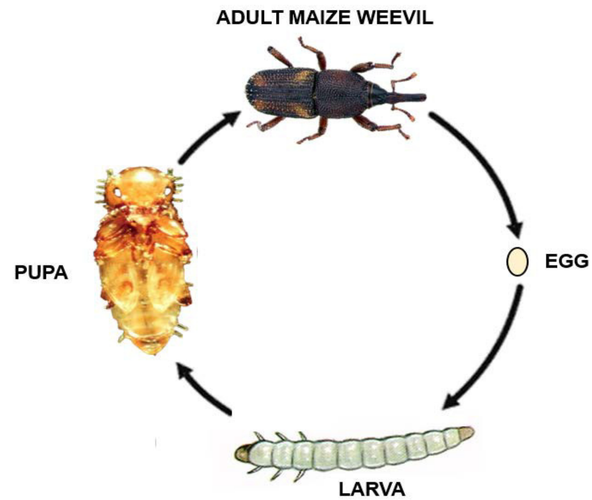

Figure 1. Life cycle of maize weevil (*Sitophilus zeamais).*

The larger grain borer (*Prostephanustruncatus*)

The larger grain borer, *Prostephanus truncatus* (Hon) (Coleoptera: Bostruchidae) also termed “Scania beetle”. It is a most destructive pest of farm-stored maize grain and dried cassava roots (Nansen and Meikle, 2002) causing weight losses of 9 % to 45 % after 5- 8 months of storage (Golob, 1988). *P. truncatus*is native to Mesoamerica (Stathers, 2002), where it is found infecting maize grain and wood (Hill *et al*., 2003). It is described as dual existence insect as both in storage pest and forest insects (Nansen *et al*., 2004). The adult *P. Trancatus* have a cylindrical bostrichid shape; the body is 3 to 4.5 mm long and dark brown in colour. This pest can also infest and cause damage to bamboo, plastic, soap, stored timber and timber products (Cabi, 2015).

Life cycle of *P. trancatus*

Adult P*. Truncates* tunnel through the stored maize grain, dried cassava or other foodstuffs, creating large quantities of dust (Cabi, 2015). *P. truncatus*is a long-lived species, the life cycle in about 4-6.5 weeks, female, live 16 days longer than male. Adult females lay small yellow ovoid (ellipsoidal) shape eggs in chambers at right angles to the main tunnels (BioNet-Earfinet, 2011). Larvae hatch from eggs after 3 to 7 days at 27-32ºC and about 50-80 % R.H (Cabi, 2015).

Storage pests of beans

Beans in Africa fall under attack by half a dozen species of bruchids: the bean bruchid or common bean weevil, *Acunthoscelides obtectus;* the cowpea bruchids *Callosobruchus chinensis* and *Callosobruchus maculutus;* the Rhodesian bean weevil, *Callosobruchus rhodesiunus;* the Mexican bean weevil or spotted bean weevil, *Zabrotes subfasciutus;* and unidentified species of *Bruchidius*. Of these, *A. Obtectus* and *Z. Subfusciutus* are the most important (Giga *et al*., 2002; Negasi, 2004**)** and occur together in many instances. *A. Obtectus* and the two *Callosobruchus* spp. occur throughout Africa, whereas Z. *Subfusciutus* has a limited distribution, *C. Rhodesiunus* occurs in southern Africa. Although bean bruchids cause substantial crop losses, little quantitative data on actual losses under field conditions are available. Negasi, (2004) reported that in Ethiopia stored bean damage by *A.obtectus* and *Z. Subfusciutus* reached up to 38%, with a corresponding bean weight loss of about 3.2%.

Figure 2. Cowpea weevil (*Callosobruchus maculutus)* damaging blacked eyed beans.

Beans weevil (*Callosobruchus maculutus*)

The cowpea weevil lacks the "snout" of a true weevil. It is more elongated in shape than other members of the leaf beetle family. It is reddish-brown overall, with black and gray elytra marked with two central black spots. The last segment of the abdomen extends out from under the short elytra, and also has two black spots (https://insects.tamu.edu/fieldguide/bimg179.html).The beetle is sexually dimorphic and males are easily distinguished from females. The females are sometimes larger than males, but this is not true of all strains. Females are darker overall, while males are brown (Figure 2). The plate covering the end of the abdomen is large and dark in colour along the sides in females, and smaller without the dark areas in males (A Handbook on Bean Beetles).There are two morphs of *C. maculatus*, a flightless form and a flying form. The flying form is more common in beetles that developed in conditions of high larval density and high temperatures. The flying form has a longer lifespan and lower fecundity, and the sexes are less dimorphic and can be more difficult to tell apart. The egg is clear, shiny, oval to spindle-shaped and about 0.75 mm long. The larva is whitish in colour (https://insects.tamu.edu/fieldguide/bimg179.html).

Life cycle of *Callosobruchus maculutus*

A female adult can lay over a hundred eggs, and most of them will hatch. She lays an egg on the surface of a bean, and when the larva emerges about 4 to 8 days later, it burrows into the bean (Fox and Reed, 2011). During development, the larva feeds on the interior of the bean, eating the tissue just under the surface, leaving a very thin layer through which it will exit when it matures. It emerges after a larval period of 3 to 7 weeks, depending on conditions. Larval crowding can occur when up to 8 or 10 larvae feed and grow within one bean. Crowding limits resources for each individual, leading to longer development time, higher mortality, smaller adult size, and lower fecundity (Beck and Blumer, 2013).Once the beetle emerges as an adult; it may take 24 to 36 hours to mature completely. The lifespan is 10 to14 days. The adult requires neither food nor water, but if offered water, sugared water, or yeast, it may consume it. A female given nutrients may lay more eggs (Beck and Blumer, 2013). The beetle tolerates a range of humidity and temperature, making it adaptable in climates worldwide. Its developmental time varies with factors such as humidity, temperature, legume type, crowding, and inbreeding levels in the population (Fox and Reed, 2011).

Management of storage pest

Pest management is an essential component of any effort to increase food production and thus ensure food security. Traditional techniques had been used in the past. These included crop rotation, intercropping, strategic flooding, and manipulation of planting dates, the setting of traps and the selection of resistant varieties. In the 19th century, pest control was revolutionized by the introduction of synthetic pesticides. This has been found to provide means of reducing pest populations massively in a more effective and large-scale manner than had ever been possible before. However, this has not brought an end to the pest problem. The future of crop pest-management based predominantly on pesticides and the dangers of pesticide use which is becoming more evident and the high cost and non-availability to the resource-poor farmers has been of great concern to Crop Protectionists. There is also a much greater problem of target insect able to develop resistance against single insect pesticide, (Boeke, 2002) or of the residual and side effect of the agent on consumers and environment.

These strains have been developing in alarming numbers among arthropods, plant pathogens, vertebrates and weeds. Thus complete reliance on pesticides for crop pest management does not appear to be a promising strategy for food security. This led to studies on alternative approaches which are not totally new but integrate all available technology as an important component of crop production system.

In Nigeria, research has also focused on the use of plant extracts and dried powders (biopesticides), notably among them is the neem *Azadirachtaindica* (seed/kernel, oil and cake, leaves, bark, roots), dry chilli peppers, onion scale leaves, ginger, tobacco, cocoa pot husks, vegetable oil, wood ash, smoke cashew nut shell liquid etc., for the control of pests in the field and in the store. Ethno-botanical research has documented traditional uses of various plants in folk medicine and protection of agricultural crops against pre-harvest and post-harvest pests (Lehman *et al*., 2007). Botanicals such as *Ocimum americanum*, *Striga senegalensis*, *Dichrotachys platycarpa*, *Parkia* sp., *Monechmahispida*, *M. scabrum*, *O. viridae* and *P. filicoidae* gave good efficacy in controlling the rust-red flour beetle (*Tribolium castaneum*) (Okunade *et al*., 2002). Neem seed powder, Eucalyptus leaf powder, garlic bulb powder caused > 45% mortality of *Callasobruchus maculatus* (Oparaeke, 1998). The good efficacy of neem seed extract and black soap against leaf spot of groundnut has been demonstrated (Alabi and Olorunju, 2004). Dry chilli pepper fruits, *Capsicum annum* and scale leaves of onion (*Allium cepa*) offered some degree of protection against *C. maculatus* damage on stored cowpea (Ofuya, 2008). *Acacia alata*, *Borelia*, *Ocimumgratissimum*, *Acalyphaciliata*, *Tamarindusindica*, *Cassia siamea* and garlic bulbs have been identified to have nematicidal properties (Egunjobi and Onayemi, 1981; Agbenin, 2004). Botanical pesticides are now being seen not as a total replacement of any particular pesticide but rather as an important input of the integrated pest management (IPM) package to reduce dependence on synthetic chemicals. Therefore, this research seeks to test the insecticidal effect of aqueous extract of garlic on the storage pest of beans and maize.

Garlic

Allium sativum is a bulb. It grows up to 0.6 m in height. Its hardness prevents insects from growing on it. It provides hermaphrodite flowers. Pollination occurs by insects such as bees. Garlic is easy to grow and can be grown year-round in mild climates. While sexual propagation of garlic is indeed possible nearly all of the garlic in cultivation is propagated asexually by planting individual cloves in the ground. In cold climates, cloves are planted in the fall, about 6weeks before the soil freezes, and harvested in late spring. Garlic plants are usually very hard, and are not attacked by many insect pests or disease. Two of the major pathogens that attack garlic are nematodes and white rot disease, which remain in the soil indefinitely once the ground has become infected.

Insecticidal effect

Garlic has a non-Selective effect and can kill beneficial insects as well. Therefore, it should be used with caution. Garlic is too toxic. The salphone hydroxyl ion penetrates the blood brain barrier and a specific poison even for higher life forms. Garlic kills anything in the way of insects as efficiently as DDT. It has also repellent properties. Garlic is reportedly effective against wide range of insects at different stages in their life cycle (egg, larvae, adult). This includes ants, moths, beetles, termites, ticks (Richard and Elzinga, 2004). It is not recommended for aphid control since it kills the natural enemies of aphids (Burnie and Tsechinkel, 2009).

MATERIALS AND METHODS

Study area

The study was conducted in the Biology laboratory, Biological Sciences Department, Faculty of Science Complex, University of Abuja main campus Airport road, Gwagwalada, Federal Capital Authority, Nigeria. Gwagwalada is located 8.9817° north, 7.1811° east as shown on satellite images (Figure 3), which has an area of 1, 043 km^2 and population of 157,770 as recorded from the 2006 national census, with and extreme hot and daily temperature of 31°C. About 60% of this rain falls between the months of July to September. The indigenes are either the *Gbagyi*or *Bassa* ethnic group (Ishaya and Obaje, 2009) (Figure 3).

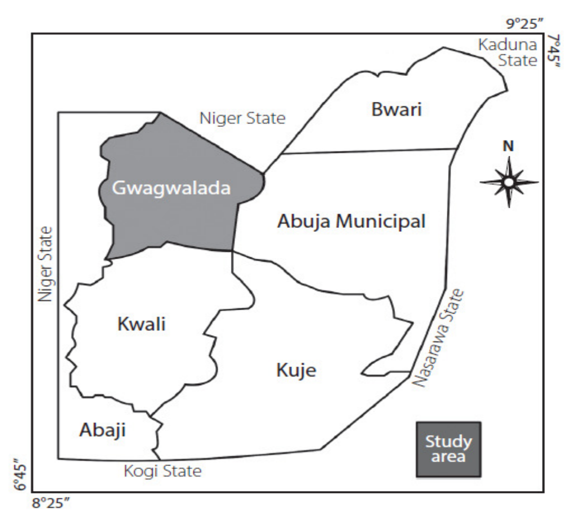

Figure 3. Map of the federal capital territory showing the study area.

Preparation of aqueous extract

Drying process

Fresh mature *Allium sativum* bulb was bought from Gwagwalada market, Gwagwalada Area Council, Federal Capital Territory, They were properly rinsed with tap water and then distilled water washed, chopped into smaller pieces with a sharp blade and dried at room temperature, to avoid loss of active compounds. The dried chopped garlic were then grinded to powder using a mortar and pestle at the Biology laboratory, Department of Biological Sciences, University of Abuja and weighed with an electric weigh balance. The powdered sample was stored in an air-tight bottle for further use.

Extraction process

The extraction process used was hot-water method (decoction) following the procedure of Handa (2008).
50 g of the powdered sample was soaked in 500 ml of distilled water and boiled for about 10 min. After boiling, the sample was double-filtered using mesh and collected in a conical flask and allowed to cool. The filtrate was dried in hot-air oven at temperature of 70°C. The plant extract obtained were stored in sample bottle.

Experimental design

Preparation of insects

The maize and beans grains were bought from a local farmer in Gwagwalada. The parent stock of the pests was obtained from infested grains. The pests were then cultured under ambient temperature of 28±2°C and 75±5% relative humidity. The food media for the insect culture were maize and beans. 500 g of each food medium was then weighed into two different glass jars. Forty adult insect pests of each grain were introduced into each culturing medium. The culturing was done for 10 days and at the end, adults of each insect pests emerged. 50 adults of each insect pest were randomly selected and transferred into another beaker and fed with maize and bean flour each for the study. (Köhler and Triebskorn, 2013).

Method of data collection

The data for the study were collected based on field experimental research principles through observation (visual inspection). The adult insects post treatment mortality for each 24 h was recorded for 5 days and on the fifth day the entire insects (both dead and alive) was separated and removed from the treated grains. Control used was powder of beans and maize each with weevils but without garlic extract (Katie *et al*., 2006).

Treatment of samples (insect bioassay)

Five beakers were used each containing the garlic extract at range 10, 20, 30, 40 and 50 mg for each of the beans and the maize weevil respectively. 1 ml of water was then added to the mixture of each of the beans and maize powder and the garlic extract in a 50 ml beaker the mixture was homogenized using a glass rod. Ten adult insect pests of each grain (harvested from the culture) were introduced to each experimental glass jar (beaker) and covered with the muslin cloth (Hostettmann and Marston, 1995).

Statistical analysis

The result was presented in percentile and comparison will be done using Histogram. ANOVA was also used for comparison.

RESULTS AND DISCUSSION

Garlic aqueous extract was used to test for toxicity against *Callosobruchus maculutus* from beans and *Sitophilus zeamais* from maize. Garlic aqueous extract showed more effectiveness against *Sitophilus zeamais* which recorded the highest mortality of 49(98%) when compared to its effectiveness against *Callosobruchus maculutus* which recorded 43(86%) mortality. Mortality effectiveness of the garlic extract on both pests increased with increased in the concentration (Tables 1-6). The result shows a very high effectiveness of different concentrations garlic aqueous extract on post-harvest pest of Beans (*Callosobruchus maculutus)* and Maize (*Sitophilus zeamais)*. *S. zeamais* recorded more mortality 49(98%) when compared to the *C. Maculutus* which recorded 43(86%) mortality (Figure 4). Increase in the concentration of the garlic aqueous extract also showed increased in mortality of both post-harvest pests tested. In the Analysis of Variance (ANOVA), the F-distribution calculated which was 0.195 for the mortality of the both post-harvest pest is less than the F-distribution tabulated which was 4.84, and this implies that there was a relationship between the extracts and mortality of the *Sitophilus zeamais* and *Callosobruchus maculutus.*

The results of this study are in line with that of Upadhyay, (2007); Rajendran and Sriranjini, (2008); Aziza and Asma, (2015); Upadhyay and Ahmed, (2011); Anyanga *et al*., (2013); Madzimure *et al*., (2013); Amoabeng *et al*., (2014); Stevenson, (2014); Kamran *et al*. (2015) who reported the effectiveness of plant extracts

Table 1. Effect of garlic extract on beans and maize pest after 24 h.

Pest	Treatments					
	Control	**One**	**Two**	**Three**	**Four**	**Five**
C.maculutus	0	2	3	5	7	8
S.zeamais	0	4	5	7	8	9

Keys:
Control - 0 mg Garlic extract
Treatment one - 10 mg
Treatment two - 20 mg
Treatment three -30 mg
Treatment four - 40 mg
Treatment five - 50 mg

Table 2. Effect of garlic extract on beans and maize pest after 48 h

Pest	Treatments					
	Control	**One**	**Two**	**Three**	**Four**	**Five**
C.maculutus	0	3	5	7	8	9
S.zeamais	0	6	7	9	10	10

Table 3. Effect of garlic extract on beans and maize pest after 72 h

Pest	Treatments					
	Control	**One**	**Two**	**Three**	**Four**	**Five**
C.maculutus	0	4	6	8	9	10
S.zeamais	0	7	8	10	10	10

Table 4. Effect of garlic extract on beans and maize pest after 96 h.

Pest	Treatments					
	Control	**One**	**Two**	**Three**	**Four**	**Five**
C.maculutus	0	5	7	8	9	10
S.zeamais	0	8	8	10	10	10

Table 5. Effect of garlic extract on beans and maize pest after 120 h.

Pest	Treatments					
	Control	**One**	**Two**	**Three**	**Four**	**Five**
C.maculutus	0	6	8	9	10	10
S.zeamais	0	9	10	10	10	10

Table 6. Percentage mortality rate of garlic aqueous extract on *Callosobruchus maculutus* and *Sitophilus zeamais.*

Pest	Total number of death	Percentage mortality (%)
C.maculutus	43	86
S.zeamais	49	98
Total	92	184

The Garlic extracts was more potent on *Sitophilus zeamais* for all concentrations.

in pest control. The use of plants in this way as insecticides not only ensures safety of the environment and consumption of the treated produces, it is reliable, readily available for production by the farmer and economical, especially for the small scaled farmers. Plants having insecticidal potentials are compelling alternative to synthetic pesticides (Anyanga *et al*., 2013; Amoabeng *et al*., 2014; Stevenson, 2014). Dust from the dried leaves of *Vernonia*sp. was also found to have insecticidal potency against larvae of *Callosobruchus maculates* (*Fabricius*) and *S. zeamais*- insects that cause heavy losses of stored cow pea and maize, respectively (Kabeh and Jalingo, 2007). Asawalam and Hassanali, (2006) also reported that the essential oil of these plants was effective in the control of *S. zeamais*.

Conclusion

This research work confirms and reports the effectiveness of garlic aqueous extract in the repellence and control of post-harvest pest *Callosobruchus maculutus* and *Sitophilus zeamais*, beans and maize respectively. And the research work also reveals that prolong exposure of the insect pests to the extracts increases efficiency in the controls of the pests. The treated beans and maize grains were not only found to be safe for consumption but also improved healthiness and growth performance. Garlic aqueous extract can be considered as easy to prepare, cheap, safe and eco-friendly possible replacement of chemical insecticides for storage pests of cereal grains.

Recommendations

(i) More research should be done on toxicity of the prolong use of the organic insecticide on human.
(ii) Both the government and private sector should invest more on the manufacturing, packaging and mass distribution of storage pest repellents and controls of natural origin such as garlic, plant origin should be encouraged to reduce the production and use of synthetic chemicals which has resulted to high ecological damage and has raised human and environmental health concerns over time.

Authors' declaration

We declared that this study is an original research by our research team and we agree to publish it in the journal.

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