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EVALUATION OF THE POTENTIAL OF GARLIC (*ALLIUM SATIVUM* L.) FOR THE MANAGEMENT OF THE LARGER GRAIN BORER - *PROSTEPHANUS TRUNCATUS* (HORN) (COLEOPTERA: *BOSTRICHIDAE*) IN MAIZE (*ZEA MAYS* L.)

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ABSTRACT

The study investigated the potential of Garlic *Allium sativum* against *Prostephanus truncatus* in stored maize. 100g disinfested maize grains were weighed into 250cm Kilner Jars using Mettler weighing balance. The grains in each jar were infested with 10 pairs of 1 day old *P. truncatus.* Thereafter 2g, 4g and 6g of powdered garlic wrapped in 4cm x 4cm sized envelops were separately inserted into maize jars. Each treatment was replicated four times and arranged on work table in the laboratory using complete randomized design. The powdered garlic was not inserted into the four control jars, but they were similarly infested. At 90 days post-infestation, the insects and dust generated were sieved out of the grains. Data on adult *P. truncatus*, number of adult mortality, weight of dust, number of damaged and undamaged grains were taken. The results showed that irrespective of application rate, the final population of LGB in the non-garlic treated jars (185.25) was significantly ($P < 0.05$) higher than 0.0, 1.0 and 3.3 obtained from maize grains treated with 6, 4 and 2gm garlic powder respectively. All the 20 LGB introduced to maize grains treated with 6g of garlic powder died. The mortality was however, not significant ($P > 0.05$) different from 19 and 18.5 mortality respectively obtained from maize grains treated with 4 and 2gm garlic powder. The mortalities were however significantly ($P < 0.05$) higher than 14 LGB in the non-garlic treated jars. The percentage grain damage in jars treated with 6g garlic powder was significantly ($P < 0.05$) lower than percentage grain damage in other treatments. There was no significant ($P > 0.05$) difference between the mean weight of dust, percentage grain weight loss and mean number of live adult LGB obtained from all garlic-treated maize. They however, differ significantly ($P < 0.05$) from data obtained from the non-garlic treated maize. The results of this study indicated that garlic powder has great potential for use in the management of *P. truncatus* in maize grains.

Key words: *Allium sativum*, application rate, maize, post-infestation, *Prostephanus truncatus*,

INTRODUCTION

Maize (*Zea mays* L.) is a member of the family Poaceae. It originated from Mexico, where it has been domesticated 10,000 years ago (ISAR, 2000). The crop is one of the most important cereal crops grown in Sub-Sahara African and ranked as the third most important cereal crop in the world after rice and wheat in terms of cultivated areas (CIMMYT, 1994). Maize is one of the most important cereal crops

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grown in sub-Saharan Africa and the third most important after rice and wheat in the world (CIMMYT, 1994). Maize is high yielding, matures early, easy to process, readily digestable, cost less than other cereals and can be grown across a range of agroecological zones (CIMMYT, 1994; Enyong *et al.*, 1999). According to FAO (2001), 589 million tonnes of maize were produced world-wide in 2000, with United States of America (USA) producing 43%, Asia 25%, Latin America and the Caribbean 13% and Africa 7% of the production. The world average yield in the same year was 4255kg per hectare. Average yield in USA was 8600kg per hectare and 1316kg per hectare in sub-Saharan African (FAO, 2001). Consultative Group on International Agricultural Research (CGIAR) in a study conducted on maize production reported phenomenal increase in maize production in West and Central Africa in recent years as a result of the introduction of high yielding, drought-tolerant and early maturing varieties (CGIAR, 1997). The introduced varieties have a yield potential of 5 tonnes per hectare and are ready for harvest as green maize in 60 days or as dry grains in 75 to 80 day. Manyong *et al.* (2000) observed that on the average, adoption of improved maize varieties resulted in a yield advantage of 45% relative to local varieties in West and Central Africa.

Every part of the maize plant has economic value; the grain, leaves, stalk, tassel and cob can be used to produce a wide variety of food and non-food products (CIMMYT, 1994). Maize has many industrial uses. The grains are used to produce oil, starch, syrup, dextrose and plastics; and it is an important source of carbohydrate, protein, iron, vitamin B and minerals. In sub-Sahara African, maize is a staple food for an estimated 50% of the population (CGIAR, 1997). Green maize is eaten baked, roasted or boiled (Purseglove, 1985). Maize is an important ingredient of balanced feeds for livestock. The high carotene content of yellow-grained maize is very useful in imparting yellow colour to egg yolk. The digestibility of maize fodder is better than sorghum and other non-legume forage crops; an attribute that favoures it in the preparation of green and dry fodder. Maize plant does not have problem of hydrocyanic acid and thus, can be fed to cattle at any stage of growth (CIMMYT, 1994). Maize contains 73.4% starch, 9.1% protein, 4.4% oil, 1.9% sugar and 1.4% ash as whole grain (FAO, 1996; Enyong *et al*., 1999).

The larger grain borer (LGB) *Prostephanus truncatus* (Horn), belong to the order Coleoptera and family Bostrichidae. The insect is indigenous to Central America, tropical South America, and the extreme south of the USA, as a major but localized pest of farm-stored maize (Chittenden, 1911). It was introduced to Tanzania in the late 1970s (Dunstan and Magazini, 1981; Golob and Hodges, 1982); and has become a serious pest of stored maize and dried cassava in that part of East Africa. The insect has since spread into southern Kenya and Burundi (Bonzi and Ntambabazi, 1993; Opolot and Odong, 1999), and may have crossed other borders. In 1984, it was found in Togo (Harnisch and Krall, 1984), and it has already spread into Benin and Ghana (Anon, 1986; Dick *et al*., 1989). At present, it has likely invaded all maize and cassava growing areas of tropical Africa, and it is the only recent example of invasion by a serious storage pest on a regional or continental scale (Hodges, 1986). Osipitan, (2005) reported the incidence of the *P. truncatus* at Idi-Iroko and Olorunda in Ogun State during pheromonal survey of the insect. The insect is a serious pest of stored maize and dried cassava tubers, and attack maize in the field just before harvest. Storage loss of maize grains as a result of infestation by *P. truncatus* is outrageous. In Nicaragua, weight losses up to 40% have been recorded from maize cobs stored on the farm for six months (Giles and Leon, 1975) and in Tanzania losses as high as 34% have been observed after 3 - 6 months farm storage with an average loss of 8.7% (Hodges *et al.*, 1983). LGB causes more damage and weight loss than *Sitophilus oryzae*, *S. zeamays* and *Sitotroga cerealella* under similar circumstances (Dick, 1988). The insect is a typical primary pest of farm-stored maize that attack shelled grains and grains on the cob.

Biologically, so far, only one predator, *Teretriosoma nigrescens* (Lewis) Coleoptera: (*Hiteridae*) has been found associated with *P. truncatus*. Rees (1985) reported that ten adult *T. nigrescens* are able to prevent populations up to 100 adult *P. truncatus* from increasing. These have drawback such as restricted adaptability of the predator to its the environment, low reproductive potential, restricted power of dispersal, high population ratio of the predator to LGB and problem of life cycle synchrony of the predator relative to LGB. Chemically, the larger grain borer has been controlled with synthetic insecticides such as permethrin, deltamethrin, phenothrin, fervalerate, DDT, BHC and phosphine (Delgado and Hernandez-Luna, 1951; Giles, 1984; Golob *et al*., 1985). However, drawbacks associated with their use such as toxicity to non-targeted organisms, development of pest resistances, persistence, pollution of the environment and underground water, biomagnifications among others has necessitated search for a relatively safer alternative strategies such as the use of extracts and powder from botanicals.

Garlic, *Allium sativum (*L) is a cosmopolitan plant, which grows in temperate zones as well as in the tropics and sub-tropics. It belongs to the family *Alliaceae* and originated in Central Asia from where it spread to the Mediterranean (Puttarodriah and Bhatta, 1955). Garlic has characteristic pungent hot flavour that mellows and sweetens considerably with cooking (Tierto, 1994), and has been used both for culinary and medicinal purposes. The insecticidal and repellent activity of garlic has been widely reported (Grainge *et al.*,1985; Rahman and Motoyama, 2000). The bulb of Garlic has been reported to possess insect controlling properties with repellant, antifeedant, bactericidal, nematicidal and fumigant mode of action that kill aphids and other soft bodied pest (Grainge *et al.*,1985). Grainge *et al.* (1985) and Kain and Kovash (1999) reported the ability of garlic to repel borers, fleas, ticks and thrips. Rahman and Motoyama (2000) reported repellency effects of garlic clove, grated garlic and its volatile extract applied on brown rice – *Nilaparuata lugen*, maize weevil – *Sitophilus zeamais* and red flour beetle – *Tribolium sp*. The volatile compounds detected by GC-MS analysis was sulfide compounds produced by rapid degradation of allicin. This study evaluates the insecticidal potential of garlic against the larger grain borer *P. truncatus* in maize.

MATERIALS AND METHODS

This study was conducted at the Entomological Research laboratory of the Department of Crop Protection, College of Plant Science and Crop Production, University of Agriculture Abeokuta (UNAAB) at 28 ± 1^0C and 79 – 82 % r.h.

Insect culture

Prostephanus truncatus used for the study was obtained from culture maintained on dried cassava chips in glass jars in the laboratory at 28 ± 1^0C and 79 – 82 % r.h. Several LGB adults of mixed sexes and unknown ages were introduced into the food media. Dust generated by feeding activities of the insects was sieved out on weekly basis to prevent excessive grain moisture content and growth of mould. Fresh food media were introduced regularly to replace depleted ones, and adults were sieved out to set up new culture to guarantee regular source of insect.

Sources of maize and garlic

The maize variety used for this study, Suwan-1 was obtained from Ogun State Agricultural Development Programme (OGADEP), Idi-aba, Abeokuta, Ogun State. The maize was disinfested in the deep freezer at temperature of -20^0C for 48hours to get rid of any insect or pathogen. They were allowed to acclimatize for 48 hours before usage. The Garlic- *Allium sativum* used for study was procured from Kuto market, Abeokuta, Ogun State. They were ground into powder using electric grinding machine and left to dry at room temperature for 48hours.

Experimental procedure

100gm maize grains were weighed into $250cm^3$ kilner jars using Mettler weighing balance (Mettler Toledo). They were infested with 10 pairs of 1 days old *P. truncatus*. Thereafter, 2, 4 and 6gm powdered garlic in 4cm × 4cm sized envelope were separately inserted into maize grains in each of the jars. Each treatment was replicated four times and arranged on work table in the laboratory using complete randomized design. The control glass jars contained 100gm maize and was infested with 10 pairs of 1 day old LGB, but were not treated with garlic. About 100gm disinfested grains were weighed into the jars to monitor change in weight of grains as a result of moisture loss or gain (Hurlock, 1967). Insects were sexed using the method of Shires and McCarthy (1976). At 90 days post-infestation, the insects and dust they generated were sieved out of the grains and the grains were separated into damaged and undamaged. The following traits were determined:

(i) Number of adult *P. truncatus*
(ii) Number of adult mortality
(iii) Weight of dust (gm)
(iv) Total number of grains
(v) Number of damaged and undamaged grains
(vi) Final weight of grains

Insects that did not move or respond to three probing with a blunt probe were considered dead (Obeng-Ofori and Reichmuth, 1997). Percentage weight lost and percentage damage, respectively, were calculated using the formulae, according to Baba Tierto (1994).

$$\%\ \text{Grain weight loss} = \frac{\text{Weight of control sample- final weight of grain} \times 100}{\text{Weight of control sample}}$$

$$\%\text{Grain damage} = \frac{\text{Number of damaged grains} \times 100}{\text{Total number of grains}}$$

Statistical analysis

Statistical analysis of data was based on SAS's general linear models procedure (SAS Institute, 1988). The data were subjected to analysis of variance (ANOVA). Significant means were compared using student's Newman-Keuls Test (SNK) at 5% level of significance.

RESULTS

Mean percentage damage and weight loss of maize grains treated with garlic powder

Table 1 shows the mean percentage damage and weight lost of maize grains treated with different rates of garlic powder. The control had the highest mean percentage (%) grain damage and the damage was significantly higher (P < 0.05) than damages in garlic-powder treated maize irrespective of application rate. Maize grains treated with 6g garlic powder had the lowest mean percentage (%) damage and it was significantly (P < 0.05) lower than mean percentage damage obtained in grains treated with 4g and 2g garlic powder that were not significantly (P > 0.05) different from each other. The highest mean percentage (%) weight loss (1.57) was recorded in the non-garlic treated maize (control) and it was (P < 0.05) significantly higher than mean percentage weight loss in garlic-treated maize grains irrespective of the rate of application. The lowest mean percentage weight loss (0.01) was obtained from maize grains treated with 6g garlic powder. It was however, not significantly (P > 0.05) different from mean percentage weight losses of 0.28 and 0.56 respectively obtained from maize grains treated with 4gm and 2gm garlic powder.

Mean weight of dust and number of Prostephanus truncatus in maize grains treated with garlic powder

Table 2 shows the mean weight of dust and number of adult larger grain borer in maize grains treated with different rates of garlic powder. The non-garlic treated maize grains had highest mean weight of dust (10.57g) generated by boring activities of the borer and it was significantly (P < 0.05) higher than 0.56, 0.28, and 0.01 respectively obtained from maize grains treated with 2, 4 and 6g garlic powder. The lowest mean weight of dust was in maize grains treated with 6g of garlic. It was however not significantly (P > 0.05) different from mean weight of dust generated from maize grains treated with 2g and 4g garlic powder. The non-garlic treated maize grains had a significantly (P < 0.05) higher mean number of adult larger grain borer. All the LGB introduced to maize grains treated with 6g garlic powder died and no live adult was seen. Irrespective of application rate, lower mean number of live adult LGB was obtained from garlic-treated maize grains. The differences between them were, however, not significant (P > 0.05).

Mean mortality of adult Prostephanus truncatus in maize grains treated with garlic powder

The mean mortality of adult LGB in garlic -powder treated maize grains is shown on Table 3. The non-garlic treated maize grains had the lowest mean mortality of adult LGB (14) and it differ significantly ($P < 0.05$) from mean mortalities in garlic-treated maize grains. All the twenty insects introduced to maize grains treated with 6g garlic powder died. The mortality was however, not significantly ($P > 0.05$) different from mean adult mortality of 19.00 and 18.50, respectively, obtained from maize grains treated 4g and 2g garlic powder.

DISCUSSION

The results of this study indicated the efficacy of garlic powder at managing the population of *P. truncatus* in maize grains. All the measured parameters in the treatments such as percentage weight loss, percentage grain damage, mean weight of grain dust, mean mortality of adult LGB and mean number of adult LGB obtained from garlic-treated maize grains were significantly ($P < 0.05$) different from those obtained from non-garlic treated maize grains. This result is consistent with the study of Kain and Kovash (1999) who reported the ability of garlic to protect crops against variety of insect pests. Likewise, Grainge *et al.* (1985) reported that garlic has insect controlling properties that repel and make the host less favourable and less prone to attack and infestation by insects. Buba *et al.* (2007) reported the effectiveness of garlic at controlling *Bemisia tabaci* and thrips- *Megalurothrips sjostedti* in cowpea.

From the study it seems the effectiveness of the garlic powder is directly related to the quantity applied. All the twenty LGB introduced to maize grains treated with 6g of garlic powder died, whereas, 95.0 % and 92.5 % LGB mortalities, respectively, were obtained from maize grains treated with 4g and 2g garlic powder. However, the relatively high LGB mortality caused by 2g garlic powder treatment indicated the high potency and insecticidal activity of garlic. The mortality of over 90% of the introduced LGB irrespective of application rate is suggestive of the high insecticidal activity of garlic. This is in agreement with the reports of Graigne *et al.* (1985) and Kain and Kovash (1999) that indicated the insecticidal, repellence, antifeedant and fumigative effects of garlic. Also, Rahman and Motoyama (2000) reported repellency effects of garlic clove, grated garlic and its volatile extract applied on brown rice – *Nilaparuata lugen*, maize weevil **–** *Sitophilus zeamais* and red flour beetle – *Tribolium sp*. and suggested that the active volatile compounds are likely to be sulfide compounds produced by rapid degradation of allicin. The deleterious effects of synthetic insecticides is now of greater concern worldwide and there is outcry for alternative control options that are less hazardous, cheaper and environmentally friendly. Garlic in this study was effective at managing the population of LGB. It may therefore be one of the alternative control options in our immediate environment. In conclusion, the results of the study showed that garlic at all the levels tested effectively prevented build-up of the larger grain borer in maize grains and could be considered for integration with other effective control options in the management of the LGB.

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Table 1: Mean percentage damage and weight loss of maize grains treated with garlic powder

Treatment level (g)	% Grain Damage±SE	% Weight Loss ±SE
6	0.91±0.45[c]	0.01±0.01[b]
4	7.18±1.42[b]	0.28±0.18[b]
2	9.0±2.48[b]	0.56±0.23[b]
0 (Control)	14.21±3.59[a]	1.57±0.1[a]

Mean values followed by the same letter in a column are not significantly different from each other (SNK, P<0.05).

Table 2: Mean weight of dust and number of adult LGB in maize grains treated with garlic powder

Treatment level (g)	Mean weight of Dust ±SE	Number of Adult LGB±SE
6	0.01±0.01[b]	0.00±0.0[b]
4	0.28±0.18[b]	1.00±2.0[b]
2	0.56±0.23[b]	3.25±2.5[b]
0	10.57±0.91[a]	185.25±2.13[a]

Mean values followed by the same letter in a column are not significantly different from each other (SNK, $P<0.05$).

Table 3: Mean number of adult LGB in maize grains treated with garlic powder

Treatment level (g)	Adult Mortality LGB ±SE
6	20.00±0.0a
4	19.00±0.82a
2	18.50±1.3a
0	14.00±1.24b

Mean values followed by the same letter in a column are not significantly different from each other (SNK, $P < 0.05$).