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# LABORATORY INVESTIGATION OF DAMAGE POTENTIAL OF LARGER GRAIN BORER - *PROSTEPHANUS TRUNCATUS* (HORN) (COLEOPTERA: BOSTRICHIDAE) ON SOME DRIED ROOT AND TUBER CROPS IN NIGERIA

**A.A.OSIPITAN[1], A. A. SOMADE[2] AND O. A. LAWAL[3]**

[1]Department of Crop Protection, University of Agriculture,
P.M.B. 2240, Abeokuta, Ogun State, Nigeria.
[2]Department of Produce Services, Ministry of Agriculture,
Abeokuta, Ogun State, Nigeria.
[3]Department of Plant Science and Applied Zoology, Faculty of Science,
Olabisi Onabanjo University, P.M.B 2002, Ago - Iwoye, Ogun State, Nigeria.
[1]Corresponding author e-mail:osipitan1@yahoo.com Tel. No.+2348033930581

## ABSTRACT

The study investigated the ability of larger grain borer (LGB) – *Prostephanus truncatus* to infest and breed on some root and tuber crops (R&TC) namely potato – *Solanum tuberosum* L.; sweet potato – *Ipomea batatas* Lam; bitter yam – *Dioscorea dumetorum* (Kunth) Pax; white yam – *D. rotundata* Poir; water yam – *D. alata* L; yellow yam – *D. cayenensis* Lam.; cocoayam - *Colocasia esculenta* L (Schott) and cassava - *Manihot esculenta* Crantz in the laboratory. The R&TC were cut into cubes of about $4cm^3$ and air dried in the laboratory. Five cubes each were separately placed in $250cm^3$ sized glass jars and infested with 10 pairs of adult LGB of between 1-5 days old for ninety days. Each treatment were replicated four times and arranged on a worktable in the laboratory using complete randomized design. Data were taken on final population of LGB, weight of frass generated, number of holes, number of adult mortality, number of larvae, number of pupae, % of damaged cube and % weight loss of cubes. Preference of LGB for the R&TC was studied in a "simple choice chamber test" conducted in a rectangular jar measuring 50cm x 30 cm x 25 cm. All the R&TC had 100 % damage except *S. tuberosum* that was not damaged nor infested. The highest mean population of adult LGB and number of holes on cubes was in *M. esculenta* and it differed significantly ($P < 0.05$) from other R & TC. Likewise, the mean weight of frass and % weight loss of cubes in *D. alata* was significantly ($P < 0.05$) higher than in other R & TC. The preference test showed that LGB preferred the R&TC in the descending order: cassava - water yam - sweet potato - yellow yam - cocoayam - white yam - bitter yam - potato.

**Keywords:** Mortality, preference test, *Prostephanus truncatus*, root and tuber crops, weight loss.

## INTRODUCTION

The major Root and tuber crops (R&TC); cassava - *Manihot esculenta* Crantz, potato – *Solanum tuberosum* L, sweet potato – *Ipomea batatas* Lam. and yam – *Dioscorea* spp are major sources of sustenance in many parts of Sub-Saharan Africa and play significant roles in the food sys-

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tems (Horton and Fano, 1985; Alexandratos, 1995). They contribute to the energy and nutrition requirements of more than 2 billion people in developing countries by serving as source of carbohydrates, vitamins, minerals, and essential amino acids such as lysine supplement (Woolfe, 1992; Low *et al.* 1997). The main nutritional value of R&TC lies in their potential ability to provide one of the cheapest sources of dietary energy in the form of carbohydrates. This energy is about one-third of that of an equivalent weight of grain, such as rice or wheat, because these crops have a high water content with low protein content that ranged between one and two percent (Gregory *et al.*, 2000).

Many households in the developing countries depend on these crops as a principal source of food and nutrition that supply large quantities of dietary energy (Alexandratos, 1995). The crops also constitute an important source of employment and income in rural areas as they have graduated from on-farm consumption to cash crop for sale to both urban and rural consumers (Nweke, 1992; Nweke *et al.*, 1994). Root and tuber crops are security crop; they supply regular food that could be consumed fresh or processed. The crops are adapted to wide usage as cash crop, feed crop and raw material for industrial uses. Between 1983 and 1996, consumption of R&TC as food in developing countries increased from 208 million metric tons (mt) to 253 million mt and their use as animal feed increased from 64 million mt to 96 million mt during the same period. Between 1995 –1997, the major R & TC occupied about 50 million hectares worldwide (Gregory *et al.*, 2000). About 70 percent of the 639 million mt of these crops produced worldwide annually were harvested in developing countries. Production of the major R&T in developing countries alone had an estimated annual value of more than US$41 billion in 1995– 97 (FAO, 1999). Cassava - *M. esculenta*, potato- *S. tuberosum*, and sweet potato – *I. batatas* rank among the top 10 food crops produced in developing countries and have become the subject of increasing attention in recent years. International Model for Policy Analysis of Agricultural Commodities and Trade (IMPACT) simulations indicate that R&TC will play an economically important and increasingly diversified roles in developing countries food systems over the next two decades (Gregory *et al.*, 2000). More than 30 edible species of R&TC are grown today; foremost among them in terms of aggregate output and estimated value of production are cassava – *M. esculenta,* potato – *S. tuberosum*, sweetpotato – *I. batatas* and yam – *Dioscorea* spp. Other prominent R&TC such as cocoyam *Colocasia esculenta* L. (Schott) and ginger *Zingiber officinales* grown across wide agroecologies also play important roles in food systems (Horton, 1988)

The larger grain borer (LGB), *Prostephanus truncatus* is an introduced insect pest of maize and dried cassava (Hodges *et al.*, 1985; Detmers, 1990; Wright *et al.*, 1993). It is a member of the family Bostrichidae, the false powder beetles which contains about 500 species and tropical in distribution. The insect has been a major pest of stored maize in Mexico and Central America for many years (Chittenden, 1911) before its accidental introduction to Africa in 1981. In Africa, it was identified as the pest causing severe loses in stored maize in

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Tanzania in 1981 (Dunstan and Magazini, 1981; Golob and Hodges, 1982); from where it spread to Togo (Harnisch and Krall, 1984), Republic of Benin (Anon, 1986), Ghana (Dick *et al*., 1989), Guinea (Kalivogui and Muck, 1990), Burkina Faso (Bosque-Perez *et al*., 1991), Nigeria (Pike *et al.,* 1992), Malawi (Munthali, 1992), Zambia (Millimo and Munene, 1993), Niger (Adda *et al.,* 1996), South Africa (Roux, 1999) and some other African countries such as Kenya, Burundi, Rwanda and Uganda (Kega and Warui, 1983; Bonzi and Ntambabazi, 1993; Opolot and Odong, 1999). LGB is highly voracious and can cause up to 40% yield loss in stored maize grains within six months (Giles and Leon, 1975) and 75% in fermented cassava roots within four months (Hodges *et al.,* 1985). In addition to causing weight loss, LGB can also reduce the nutritional composition of infested grains, particularly amino acids, lysine, tryptophan and level of grain viability (Adem and Bourges, 1981; Torreblanca *et al.,* 1983). The adult beetle and its larval stages cause damage to a wide range of commodities including, cereals, pulses, cocoa, coffee, groundnut and wooden structures (Booth *et al.,* 1990; GASGA, 1993; Espinal *et al.,* 1996). The voraciousness of LGB, its wide host range and ability to reduce the nutritional composition of infested crop constitute a threat to crop production in African. This study investigated the ability of LGB to damage and breed on some root and tuber crops in Nigeria.

## MATERIALS AND METHODS

***Insect culture***

*Prostephanus truncatus* used for the study was obtained from culture maintained on dried cassava chips in 250cm$^3$ glass jars in the laboratory at temperature and relative humidity of 28$\pm$1$^0$C and 79 – 82 % r.h. Several LGB adults of mixed sexes and unknown ages were introduced into the culture media. Frass generated by feeding activities of the insects was sieved out on weekly basis using sieve of mesh size 0.25mm to prevent excessive grain moisture content and growth of mould. Culture media were rejuvinated monthly to replace depleted ones, and adults were sieved out to set up new culture to guarantee regular source of insect.

***Study of population emergence of P. truncatus in glass jars***

Some root and tuber crops namely sweet potatoes – *Ipomea batatas* L (Lam.), cassava – *Manihot esculenta* Crantz, potato – *Solanum tuberosum*, cocoayam – *Colocasia esculenta* (L) Schott, white yam – *Dioscorea rotundata* Poir, water yam – *D. alata* L., yellow yam – *D. cayenensis* Lam., and bitter yam – *Dioscorea dumetorum* (Kunth) Pax; were screened for damage and breeding by LGB in the Entomology Research Laboratory, University of Agriculture, Abeokuta. The R & TC were cut into cubes of about 4 cm$^3$ and naturally air dried on the worktable in the laboratory for three weeks. The moisture content was determined by dry oven method (Oxley and Pixton, 1960) and weight of cubes determined using Mettler weighing balance (Tonedo 223). Five cubes each of the root and tuber crops were placed in 250cm$^3$ sized glass jars and infested with 10 pairs of adult LGB of between 1-5 days old. Cassava – *M. esculenta,* one of the primary hosts of LGB was included in the trial as a reference media. The treatments were replicated four times and arranged on a work-table in the laboratory using complete randomized design. Five un-infested cubes of each root and tuber crops were weighed and placed in glass jars to monitor moisture loss or gain in the test media. The introduced insects were left on the R&TC for three months at temperature and relative humidity of 28$\pm$1$^0$C and 79 – 82 % r.h; after which the following data were taken:

(i) Number of holes on the yam cubes
(ii) Adult LGB emergence (mortality and alive)
(iii) Instars emergence
(iv) weight loss in root and tuber crops

The percentage weight loss was calculated according to Baba-Tieto Niber (1994) using the formula:

$$\%\text{ weight loss} = \frac{\text{Initial weight of sample before infestation} - \text{final weight sample after infestation}}{\text{Initial weight of sample before infestation}} \times 100$$

The cubes of the R&TC were adjusted for moisture gain before calculation of percentage weight loss. The data collected were subjected to analysis of variance (ANOVA, P < 0.05) and means separated using Duncan's Multiple Range Test (DMRT). Arc-sine transformation of data in percentage was done before ANOVA.

***Preference test***

Lots of cubes used for study in glass jars were used to study preference of LGB in a simple choice chamber test in the laboratory at 28$\pm$1$^0$C and 79 – 82 % r.h. Four cubes each of the R&TC were placed in a rectangular glass tank measuring 50cm x 30 cm x 25 cm (Length x Breadth x Height) in concentric ring along the length and breadth of the tank. The floor of the glass tank was laid with a cardboard to provide a surface for the movement of the insects (Hodges *et al.,* 1985). The glass tank was covered with a wire net and held in place with a rectangular wood constructed to fit the top of the glass tank. Two-hundred (200) adult LGB of between 1- 5 days old were placed in the center of the glass tank. At 72 hours after infestation, the following data were taken:

(i) Number of LGB in each cube
(ii) % of cubes damaged
(iii) Number of holes in each cube

## RESULTS

***Mean number of holes on root and tuber crops infested by P. truncatus***

As shown in Table 1, the highest mean number of holes was bored on *M. esculenta*, the reference media and it was significantly higher (P < 0.05) than mean number of holes bored on other R&TC. The lowest mean number of holes was bored on *D. cayenensis* and it differed significantly (P < 0.05) from mean number of holes bored on other R&TC.

All the five cubes of the R&TC were infested except *S. tuberosum* that was not infested nor damaged. This 100% cubes infestation by LGB was significantly (P < 0.05) higher than 0 % cube infestation in *S. tuberosum*.

**Table 1: Mean % of cubes damaged and number of holes on LGB-infested root and tuber crops.**

| Root and tuber crops | % of cubes damaged±SE | Mean number of holes on cubes ±SE |
|---|---|---|
| *Dioscorea rotundata* Poir | 100.00±0.0a | 185.25±1.6d |
| *Dioscorea alata* L. | 100.00±0.0a | 206.00±1.9b |
| *Dioscorea dumetorum* (Kunth) Pax | 100.00±0.0a | 95.75±1.8f |
| *Dioscorea cayenensis* Lam. | 100.00±0.0a | 72.75±1.7g |
| *Ipomea batatas* Lam. | 100.00±0.0a | 199.25±1.4c |
| *Solanum tuberosum* L. | 0.00±0.0b | 0.00±0.0h |
| *Colocasia esculenta* L. (Schott) | 100.00±0.0a | 175.25±1.9e |
| *Manihot esculenta* Crantz | 100.00±0.0a | 225.00±1.1a |

Means followed by the same letter in each column are not significantly different ($P > 0.05$) according to Duncan's Multiple Range Test (DMRT).

***Population emergence of adult P. truncatus on infested root and tuber crops.***

Table 2 shows the mean population emergence of live and dead adult LGB in the infested R&TC. The mean population of living LGB in the reference media was significantly ($P < 0.05$) different from that in other R&TC. The highest number of living LGB was in *M. esculenta*, the reference media, followed by *D. alata*, *I. batatas*, *D. rotundata*, *C. esculenta*, *D. dumetorum, D. cayenensis and S. tuberosum*. All the twenty LGB introduced into *S. tuberosum* died and did not breed. The highest number of insect mortality was in *D. cayenensis* and it was significantly ($P < 0.05$) higher than mortality in other R&TC except *S. tuberosum*.

***Population emergence of P. truncatus instars on infested root and tuber crops.***

Table 3 shows the mean population of LGB instars in the infested R&TC. The larvae and pupae of LGB were not seen in *D. cayenensis* and *S. tuberosum*. The highest mean number of larvae were recorded in *C. esculenta* and it was significantly ($P < 0.05$) higher than number of larvae from other R&TC. The number of pupae in *I. batatas* and *C. esculenta* were not significantly ($P > 0.05$) different from each other; they were however, significantly ($P < 0.05$) higher than number of pupae from other R& TC.

**Table 2: Mean population of adult *Prostephanus truncatus* on infested root and tuber crops.**

| Root and tuber crops | Mean numbers of adult LGB±SE alive | Mean numbers of adult LGB±SE dead |
|---|---|---|
| *Dioscorea rotundata* Poir | 32.00±2.2c | 11.00±0.7c |
| *Dioscorea alata* L. | 64.50±2.1b | 6.50±0.2d |
| *Dioscorea dumetorum* (Kunth) Pax | 20.5±1.3d | 15.75±0.9b |
| *Dioscorea cayenensis* Lam. | 14.75±1.7f | 22.75±1.1a |
| *Ipomea batatas* Lam. | 33.50±2.1c | 6.75±0.8d |
| *Solanum tuberosum* L. | 0.00±0.0e | 20.00±0.0a |
| *Colocasia esculenta* L. (Schott) | 22.25±2.2d | 14.00±0.7b |
| *Manihot esculenta* Crantz | 116.50±2.4a | 9.00±0.6c |

Means followed by the same letter in each column are not significantly different (P > 0.05) according to Duncan's Multiple Range Test (DMRT).

**Table 3: Mean population of *Prostephanus truncatus* instars on infested root and tuber crops.**

| Root and tuber crops | Mean numbers of LGB instars±SE Larvae | Mean numbers of LGB instars±SE Pupae |
|---|---|---|
| *Dioscorea rotundata* Poir | 6.25±0.6e | 4.25±0.5c |
| *Dioscorea alata* L. | 4.50±0.3e | 1.50±0.3d |
| *Dioscorea dumetorum* (Kunth) Pax | 12.75±1.1c | 8.25±0.6b |
| *Dioscorea cayenensis* Lam. | 0.00±0.0f | 0.00±0.0e |
| *Ipomea batatas* Lam. | 9.25±0.4d | 14.25±0.6a |
| *Solanum tuberosum* L. | 0.00±0.0f | 0.00±0.0e |
| *Colocasia esculenta* L. (Schott) | 33.00±1.3a | 13.00±0.6a |
| *Manihot esculenta* Crantz | 16.75±1.2b | 3.75±0.4c |

Means followed by the same letter in each column are not significantly different (P > 0.05) according to Duncan's Multiple Range Test (DMRT).

**Table 4: Mean weight of frass and % weight loss of root and tuber crops infested with *Prostephanus truncatus.***

| Root and tuber crops | Mean weight of frass±SE | % Weight loss of cubes ±SE |
|---|---|---|
| *Dioscorea rotundata* Poir | 6.57±0.2c | 17.87±1.3e |
| *Dioscorea alata* L. | 17.47±0.1a | 52.90±0.1a |
| *Dioscorea dumetorum* (Kunth) Pax | 2.89±0.0d | 18.05±1.2e |
| *Dioscorea cayenensis* Lam. | 2.74±0.0f | 1.50±0.1f |
| *Ipomea batatas* Lam. | 11.61±0.3c | 48.63±1.6b |
| *Solanum tuberosum* L. | 0.00±0.0e | 0.00±0.0f |
| *Colocasia esculenta* L. (Schott) | 7.14±0.1d | 22.87±1.4d |
| *Manihot esculenta* Crantz | 13.47±0.2b | 50.03±0.3c |

Means followed by the same letter in each column are not significantly different (P > 0.05) according to Duncan's Multiple Range Test (DMRT).

***Weight loss in root and tuber crops infested by P. truncatus***

Mean weight of frass and % weight loss of R&TC infested with *P.* ***truncatus*** were determined. As shown on Table 4, mean weight of frass and % weight loss in *D. alata* as a result of infestation and feeding activities of LGB was significantly (P < 0.05) higher than that in the reference media, *M. esculenta*. The lowest mean weight of frass and % weight loss was from *D. cayenensis* and it was significantly (P < 0.05) lower than that from other R&TC except *S. tuberosum* that was not damaged at all.

***Preference test***

Table 5 shows the results of the preference test in a simple choice chamber. The "preference parameters" (mean number of LGB in cubes, mean number of holes and % of cubes infested) suggested that *M. esculenta*, the reference media was most preferred. The highest mean number of LGB, mean number of holes bored by the insect and percentage of cubes infested was on *M. esculenta*, the reference media and they were significantly higher (P < 0.05) than number of LGB, number of holes bored and % of cubes infested in other R&TC. The next most preferred host was *D. alata*, as it recorded the next higher mean number of LGB, mean number of holes bored by the insect and percentage of cubes infested. The least preferred of the R&TC was *S. tuberosum* and it was significantly (P < 0.05) different from other R&TC. As indicated by the preference parameters, the preference of LGB for the R&TC was in descending order: cassava - water yam - sweet potato - white yam - yellow yam - cocoayam - bitter yam - potato.

**Table 5: Mean number of adult LGB, % of cubes infested and number of holes in root and tuber crops infested in a preference test**

| Root and Tubers | Mean number of adult LGB $\pm$SE | % of cubes infested | Mean number of holes $\pm$SE |
|---|---|---|---|
| *Dioscorea rotundata* Poir | 4.25$\pm$2.1d | 100.00 | 4.25$\pm$1.6c |
| *Dioscorea alata* L. | 12.00$\pm$1.1f | 100.00 | 9.50$\pm$0.0e |
| *Dioscorea dumetorum* (Kunth) Pax | 1.50$\pm$1.5b | 50.00 | 1.00$\pm$0.0a |
| *Dioscorea cayenensis* Lam. | .50$\pm$1.3.0c | 50.00 | 2.00$\pm$0.0a |
| *Ipomea batatas* Lam. | 8.25$\pm$1.3e | 100.00 | 7.00$\pm$0.0d |
| *Solanum tuberosum* L. | 0.00$\pm$0.0a | 0.00 | 0.00$\pm$0.0b |
| *Colocasia esculenta* L. (Schott) | 2.00$\pm$1.1bc | 50.00 | 1.00$\pm$0.0a |
| *Manihot esculenta* Crantz | 19.50$\pm$0.2g | 100.00 | 15.75$\pm$1.1f |

Means followed by the same letter in each column are not significantly different (P > 0.05) according to Duncan's Multiple Range Test (DMRT).

## DISCUSSION

The study indicated the ability of the LGB to damage and breed on dried sweet potato – *I. batatas*; bitter yam – *D. dumentorum*; white yam – *D. rotundata*; water yam – *D. alata*; yellow yam – *D. cayenensis*; cocoayam – *C.. esculenta* and cassava – *M. esculenta*. This result is similar to that of Nyakunga (1982) who reported the ability of the insect to breed and reproduce on dried cassava – *M. esculenta*. The adult LGB and its larval stages have been reported to cause damage to a wide range of commodities including, cereals, pulses, cocoa, coffee, groundnut, wooden structures and materials with no evidence of breeding on wood, perspex and polythene (Chittenden, 1911; Booth *et al.,* 1990; Espinal *et al.,* 1996). The high percentage mean weight loss recorded in *D. alata* (52.90), *M. esculenta* (50.03) and *I. batatas* (48.63) within three months of infestation by the insect supported earlier reports by Giles and Leon (1975) and Hodges *et al.*(1985) that the insect is highly voracious. It has been reported to cause 40% yield loss in stored maize grains within six months (Giles and Leon, 1975) and 75% in fermented cassava roots within four months (Hodges *et al.*, 1985). The yam powder from infested R&TC could be a measure of damage done to them. Hodges *et al.* (1983) reported that more damage is done to infested grains through conversion of maize grains to maize flour by boring activities of LGB. The relatively high damage indices (number of adult LGB, % of damaged cubes, %weight loss, number of holes bored) recorded on *D. alata* and *I. batatas* indicated higher preference for them after *M. esculenta*. This substantial damage of the R&TC by LGB may negate the importance of the crops as a cheaper source of carbonhydrate to middle-class and low-income earners that could not afford the more costly sources of carbohydrate such as rice and wheat. Adem and Bourges (1981) and Torreblanca *et al.* (1983) reported that LGB can reduce the nutritional composition of infested grains, particularly amino acids, lysine, tryptophan and level of grain viability. Subramanyam *et al.* (1987) reported that burrowing activity of LGB cause direct damage to germ and substantially reduced seed viability. The presence of larvae and pupae on the R&TC and increase in the final population of the insect indicates breeding by the introduced LGB. Though, the insect has been reported to be able to bore and damage wide host range of commodities (Booth *et al.*, 1990; Espinal *et al.*, 1996); its ability to breed on the candidate R&TC in these studies except *S. tuberosum* aggravate the threat of LGB to R&TC. Bell and Watters (1982) reported that the insect has a short life cycle of 24 - 25 days at optimum temperature of $32^0$C and rh of 70 - 80 %. Li (1988) reported that the oviposition of LGB spanned through life and adults commonly live for more than 100 days under laboratory conditions. All these are attributes that favoures build up of LGB within short period in infested commodities. Since R&TC have not be reported to be infested by LGB underground, but during storage and processing. It may thus be logical if they are left underground until needed. Since LGB generated substantial powder from the infested R&TC as a result of its feeding activities in these studies, further studies should be conducted on the effects of LGB feeding on nutritional composition of R&TC; especially the proximate composition.

The study indicated that sweet potato – *I. batatas*; bitter yam – *D. dumentorum*; white yam – *D. rotundata*; water yam – *D. alata*; yellow yam – *D. cayenensis*; cocoayam – *C.. esculenta* and cassava – *M. esculenta* could be infested, damaged and bred on by LGB. The R&TC are preferred in descending order: cassava - water yam - sweet potato - white yam - yellow yam - cocoayam - bitter yam - potato.

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