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Full Length Research Paper

A survey of pests of stored Ginger [*Zingiber officinale* (Rosc.)] in some selected markets in Rivers State, Nigeria

U. Zakka*, N. E. S. Lale and V. C. Okereke

Department of Crop and Soil Science, Faculty of Agriculture, University of Port Harcourt, Port Harcourt, Nigeria.

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Two seasonal surveys were carried out in March/April and June/July, 2009 to identify insect pests of stored ginger. Dried ginger was randomly obtained from old stocks in 10 local markets within the Port Harcourt metropolis and the study was laid out in a simple CRD and each treatment was replicated 4 times. Potato dextrose agar medium was used to isolate the fungal organisms. The results show that mites were the most abundant ($P \leq 0.05$) arthropods and they were followed by *Lasioderma serricorne* in stored ginger during the two sampling periods. Sample collected in March/April indicated that mean number of arthropod pests that emerged from Rumuomasi market was significantly higher ($P \leq 0.05$) and the lowest number was recorded in ginger obtained from Oil Mill and Abuloma markets. Mean weight loss (g) was significantly higher in samples obtained from the fruit garden market ($P \leq 0.05$). Quantitative loss due to arthropod infestation was lowest in ginger sampled from Abuloma market. In the June/July season weight loss was significantly higher in ginger obtained from Creek road ($P \leq 0.05$) and the lowest weight loss (g) was recorded in ginger obtained from Rumuomasi and Mile 3 markets. *Aspergilus flavus*, *Aspergilus niger*, *Fusarium oxysporium* and *Rhizopus* sp. were isolated from the dried ginger samples with *A. flavus* having high occurences. The survey has shown that in Rivers State, stored ginger is not immune to arthropod pest infestation and fungal infection. It has also shown that seasonal variation affects the population dynamics of arthropod pests of stored ginger.

Key words: Arthropods, ginger, fungi, pest, infestation, infection.

INTRODUCTION

Ginger [*Zingiber officinale* (Rosc.)] is a perennial root crop that is cultivated in almost all the tropical and sub-tropical regions of the world (Kannan and Nair, 1965). Nigeria is currently the world's fifth largest producer and exporter of ginger especially the split-dried ginger (Arene et al., 1986). The crop is commercially grown for its aroma, and the rhizomes are used both as a spice and for medicinal purposes (Kannan and Nair, 1965). It contains up to 5% starch and 3% volatile oils with zingiberone as the main component (McGee, 2004); these essential oils give the spice its fragrance (Jakes, 2007; Ebewele and Jomoh, 1988). Other important components of ginger include acid-soft resin which is insoluble in ether and oil, gum, lignin, vegetable matter, asmazone, acetic acid, acetate of potash and sulphur (Meadows, 1988; McGee, 2004). Oleoresin found in ginger is an active ingredient which aids digestion; it also serves as anti-flatulence, anti-tussive, laxative and its antacid compounds also reduce the severity and duration of chemotherapy-induced nausea (Ernst and Pittler, 2000). Ginger is widely utilized extensively for a variety of purposes such as spice in cooking, flavour in beverages and pastries (Meadows, 1988; McGee, 2004) and flavouring for cookies, cracker and cakes (Jakes, 2007). Ginger is also used for its aesthetic appeal and as a landscaping material around sub-tropical homes (McGee, 2004).

The two commercial varieties commonly grown in Nigeria are 'Taffin Giwa' or elephants foot and 'Yatsun Biri' or monkey finger. Other exotic varieties in Nigeria include Maran, Himachal Pradesh, St. Vincent, Rio-de-Janeiro and Wynad local (Asumugha et al., 2006).

A major constraint in ginger cultivation and storage is

*Corresponding author. E-mail: uzakka@yahoo.com. Tel: +234(0)8065703350.

the activity of insect pests on the field and in storage (Nambiar and Sarma, 1974). It is also rife with diseases which include fungal (soft spot, yellows, leaf-spot disease, banded leaf blight, helminthosporium leaf spot, golletotrichum leaf spot), viral (mosaic disease of ginger, chlorotic fleck virus, chirke virus infection), bacterial diseases (bacterial soft-rot caused by phytoplasma and bacterial wilt caused by *Pseudomonas solanacaenum*) (Ravindran and Nirmal Babu, 2004) and nematodal diseases caused by root knot nematodes such as *Meloidogyne incognita* and *Meloidogyne javanica* (Sharma and Jain, 1977).

Ravindran and Babu (2005) observing the activity of pest in ginger production noted that infestation resulted to shrivelling of buds and rhizomes and this also affected sprouting adversely, whereas infestation in store can result in 4.0 - 22.5% when stored for 128 and 175 days respectively. Joseph et al. (2001) while looking at the extent of damage caused by insect pest on stored ginger reported that a gradual infestation starts from the second month of storage. Insect pests and disease of stored ginger have not been investigated in Nigeria and little has been reported in the literature. The purpose of this study, therefore, was to survey insect pests and fungal species associated with stored ginger in the humid tropics of Nigeria.

MATERIALS AND METHODS

Materials and experimental design

Dried ginger rhizomes were randomly sampled from old stocks in 10 local markets where ginger is mainly sold in Port Harcourt metropolis, Rivers State, Nigeria. The markets are Choba, Rumuokoro, Oil mill, Fime´ (Abuloma), Mile 3, Fruit garden, Mile 1, Creek road and New layout Market, respectively. Sampling was done from these markets in March/April and June/July, 2009 and kept in 1-L Kilner jars. The covers to the jars were perforated in the middle to allow for ventilation.

Ginger samples were weighed using a digital balance (AMW-550 model) to know the initial weight. Each sample was kept in a 1-L Kilner jar, labelled and placed on an open shelf in a laboratory (25 – 28°C and 70 – 90% R. H.) in Faculty of Agriculture General Laboratory, University of Port Harcourt. The set-up was laid out in a simple complete randomized block design with 4 replicates. The experiment was monitored for 30 days for insect pest emergence.

Experimental procedure

Insect pests count

Data on insect count was taken by carefully emptying the content of each jar on a white sheet of paper and observing the presence. Insects were counted and removed using a soft brush and kept in a vial containing 75% alcohol for preservation and identification. The content of each jar was returned and kept in its original position. Insects species collected were identified in the Animal and Environmental Biology - Entomology Laboratory and confirmation was done in the Faculty of Agriculture, Crop Protection Unit, while fungal identification was done in the Plant Science and Bio-Technology Department all in the University of Port Harcourt.

The collection was repeated in June/July of the same year for reproducibility of data and to compare the infestation period across dry and wet seasons.

Weights of the samples were taken at the end of the storage period to calculate weight loss due to insect pest activity by using a simple calculation as: F_1 - F_2 and expressed as simple percentage (where F_1= Initial weight; F_2= Final weight). The data obtained for each parameter in each collection period were subjected to ANOVA. Means were separated using LSD at 5% level of probability.

Fungi isolation

The samples were assessed and fungal species isolated using potato dextrose agar (PDA). The isolation and identification of the causal agents were performed for every single rotting sample. Samples were surface sterilized with 70% alcohol for 60 s, washed in sterile distilled water and blotted dry with sterile filter paper. The infected parts were sliced into small segments and placed onto PDA in 9 cm petri dishes. The plates were incubated at 28±2°C for 3 days. Sub culturing was done until pure cultures of the isolates were obtained and maintained.

RESULTS

The number of arthropods observed in sampled ginger in March/April indicated that mites were the most abundant ($P \leq 0.05$) arthropods, followed by *Lasioderma serricorne* which differed significantly from the number of *Trogoderma granarium* recorded. However, numbers of other insects observed did not differ from each other in all the markets sampled. Number of arthropod pests that emerged from samples collected from Rumuomasi market was significantly higher ($P \leq 0.05$), followed by Mile 3 and Mile 1 markets and the lowest number occurred in samples obtained from Oil Mill and Abuloma markets (Table 1).

Table 2 shows the weight loss (g) of ginger sampled in March/April and that Fruit garden was significantly different ($P \leq 0.05$) followed by Mile 1 and Mile 3 markets which also differed significantly from each other. Quantity loss due to arthropod activity during the period was least in ginger sampled from Abuloma market. Table 3 shows the number of arthropods recorded in stored ginger sampled from 10 markets in Rivers State in June/July. Number of mites observed was significantly higher ($P \leq 0.05$) than the numbers of other arthropods followed by *L. serricorne*. Besides the mites, there were no significant differences between the numbers of insects recorded from the 10 markets.

Table 4 shows the weight loss (g) of ginger due to arthropod pest infestation in the months of June/July. The result indicated that ginger obtained from Creek road market recorded a significantly higher ($P \leq 0.05$) weight loss than samples obtained from other markets. The least weight loss (g) was recorded in ginger obtained from Rumuomasi and Mile 3 markets.

Table 5 shows that four fungal species- *Aspergilus flavus*, *Aspergilus niger*, *Fusarium oxysporium* and *Rhizopus* sp.- were consistently isolated from the dry

Table 1. Mean number of arthropods of ginger sampled in April 2009 in ten market sites.

Insect species	CH	RK	OM	RS	AB	M3	FG	M1	CR	NM	Total	Mean
L. serricone	22^{c}	28^{b}	18de	14^{f}	18de	16^{ef}	28^{b}	26^{ef}	38^{a}	19^{d}	227	22.7
T.granarium					7^{b}			17^{a}			24	2.4
D. thoracica		3^{a}							4^{a}		7	0.7
W. piger		2^{a}			1^{a}				2^{a}		5	0.5
C. cuprina			9^{a}	9^{a}							18	1.8
E. cautella			4^{a}				1^{b}			1^{b}	6	0.6
A. latinotus							7				7	0.7
Parasitic wasp						1^{a}	1^{a}				2	0.2
Mites	122^{c}	103^{f}	91^{h}	132^{b}	96^{g}	152^{a}	98^{g}	115^{d}	89^{h}	111^{e}	1109	110.9
Total	114	136	122	115	122	169	135	158	133	131	1405	
mean/9	16	15.1	13.56	25.83	13.56	18.78	15	17.56	14.8	14.56		

Means with the same superscripts in the same row are not significantly ($P > 0.05$) different; LSD = 0.05 (2.05); CV = 8.35%. CH- Choba market, RK- Rumuokoro market, OM- Oil mill market, RS- Rumuomasi market, AB- Abuloma market, M3- Mile 3 market, FG- Fruit garden Market, M1- Mile 1 market, CR- Creek road market and NM- New market, respectively.

Table 2. Mean weight loss (g) of ginger due to arthropod pest infestation sampled in April 2009.

Market	Sample 1	Sample 2	Sample 3	Sample 4	Total	Mean
Choba	21.43	26.59	24.72	32.55	105.29	26.32^{h}
Rumuokoro	29.80	26.33	20.44	33.84	110.41	27.60^{fh}
Oil mill	28.91	32.51	27.32	44.61	133.35	33.34^{d}
Rumuomasi	38.78	27.17	35.32	31.64	132.91	33.23^{d}
Abuloma	29.59	24.04	15.8	22.37	91.80	22.95^{i}
Mile 3	35.27	36.42	41.32	31.30	144.31	36.08^{c}
Fruit garden	46.56	70.17	30.42	55.95	203.10	50.78^{a}
Mile 1	44.41	47.04	37.58	41.67	170.70	42.68^{b}
Creek road	41.79	37.53	24.44	10.60	114.36	28.59^{ef}
New market	35.34	34.45	27.90	23.69	121.38	30.35^{e}

Means with the same superscripts in the same column are not significantly ($P > 0.05$) different. LSD = 0.05 (2.21); CV = 2.11%.

Table 3. Mean number of arthropods of ginger sampled in June - July 2009 in ten market sites.

Insect species	CH	RK	OM	RS	AB	M3	FG	M1	CR	NM	Total	Mean
L. serricone	2^{a}	2^{a}		2^{a}		3^{a}	2^{a}	2^{a}	4^{a}	3^{a}	20	2
T. granarium					2^{a}			2^{a}			4	0.4
D. thoracica									1^{a}	2^{a}	3	0.3
W. piger				1^{a}		2^{a}					3	0.3
A. latinotus						2^{a}					2	0.2
Parasitic wasp	2^{a}						2^{a}				4	0.4
Mites	5^{bc}	4^{cd}	4^{cd}	2^{d}	11^{a}	7^{b}	4^{cd}	3^{cd}	2^{d}	4^{cd}	46	4.6
Total	9	6	4	5	13	14	8	7	7	9	82	
Mean	1.3	0.9	0.57	0.71	1.86	2	1.14	1	1	1.29		

Means with the same superscripts in the same row are not significantly ($P > 0.05$) different. LSD = 0.05 (2.25); CV = 1.81%. CH- Choba market, RK- Rumuokoro market, OM- Oil Mill market, RS- Rumuomasi market, AB- Abuloma market, M3- Mile 3 market, FG- Fruit garden, M1- Mile 1 market, CR- Creek road market and NM- New market, respectively.

ginger sampled. *A. flavus* produced greenish mass of hyphae which covered the whole of the rhizomes. *F. oxysporium* showed water soaked lesions on infected ginger samples. The fruits were completely disintegrated

Table 4. Mean weight loss (g) of ginger due to insect pest infestation sampled in June - July 2009.

Market	Sample 1	Sample 2	Sample 3	Sample 4	Total	Mean
Choba	19.59	13.74	33.85	17.23	84.41	21.10 [b]
Rumuokoro	20.25	16.89	16.74	12.25	66.13	16.53 [de]
Oil mill	17.88	19.43	18.93	18.56	74.08	18.70 [cd]
Rumuomasi	14.87	5.62	15.63	16.79	52.91	13.23 [g]
Abuloma	19.91	20.59	20.92	19.89	81.31	20.33 [bc]
Mile 3	14.95	12.30	8.20	19.73	55.18	13.80 [fg]
Fruit garden	11.03	17.04	15.26	13.56	56.89	14.22 [fg]
Mile 1	13.06	17.31	18.12	14.16	62.65	15.66 [ef]
Creek road	8.80	22.42	64.08	16.41	111.71	27.93 [a]
New market	21.76	19.55	13.23	20.64	75.18	18.80 [c]
LSD(0.05)						2.21

Means with the same superscripts in the same row are not significantly (P > 0.05) different. LSD = 0.05 (2.21); CV = 2.38%.

Table 5. Fungi isolated from dry ginger sampled from April to July, 2009.

Market	*Aspergilus flavus*	*Aspergilus niger*	*Fusarium oxysporium*	*Rhizopus* sp
Choba	+	+	-	-
Rumuokoro	+	-	+	+
Rumuomasi	+	+	-	+
Creek road	+	+	+	+
Town market	+	-	+	+
Fruit garden	+	+	+	-
Abuloma	-	+	+	-
Oil mill	+	-	+	+
Mile 3	+	-	+	-
Mile 1	+	-	+	-

+ Present; - Absent.

and covered with white cottony mycelium and pinkish mass of fungi spore. *A. niger* formed a black mycelium and the diseased parts did not exude water freely. *Rhizopus* sp produced whitish grayish mycelium. The rot was wet and water oozed out freely from the fruits giving off an offensive odour. *A. flavus* had the highest occurrence followed by *F. oxysporium*, *A. niger* and *Rhizopus* sp in a descending order. The fungi were all of economic importance since they caused varying degrees of rot to the ginger samples.

DISCUSSION AND CONCLUSION

The survey has shown that stored ginger in Rivers State is not immune to arthropod pest infestation. It has also shown that seasonal variation affects the population dynamics of arthropod pests of stored ginger. The high number of pests observed from samples collected in March/April compared to the low population observed from those sampled in June/July across the 10 market sites could partly be explained by the meteorological differential between the periods in the period and time of harvest and the length of time it took in storage. The result followed the same trend as observed by Lale and Igwebuike (2002) while studying the field infestation of *Faidherbia* (*Acacia*) *albida* pods by stored product insects in the savanna region of Nigeria. The study of Lale and Igwebuike (2002) showed that lowest population of beetles was collected in June while highest population occurred in February.

The finding from this survey also concurs with Maina and Lale (2006) in their study on bruchids and they indicated that the beetles developed better in the raining season which was characterized by high temperature and humidity. The low number of insects observed in ginger sampled in the months of June/July which is character-rized by high humidity (80 - 95%), low temperature and high rainfall did not concur with the findings of Fields (1992) that insects die at low humidity from the effects of desiccation and susceptibility to heat. It is also believed that at low and high moisture contents, the rates of population increase are low but are highest at an intermediate optimum (Haines et al., 1991). It is therefore important for a detailed research to be carried out regarding time of harvest of ginger from the production area and duration in store to shed more light on this behavior.

The variations observed over the two periods might also be partly attributed to time of harvest and duration of storage as observed by Arthur et al. (2006) who reported that the population density of pest species is related to season and harvest time.

Although weight losses can occur from loss of moisture, it is well-known that they are occasioned principally by pest infestation (Haines, 1991). It is therefore evident from the weight loss recorded that ginger is not immune to storage pest and that pest infestation can lead to great loss if left unprotected. Increase in pest population density will lead to a corresponding decrease in weight of stored products. It has been observed that stored ginger is associated with diverse species with lots of storage pests with mites being the most predominant followed by *L. serricorne*. Seasonal variations greatly influences the relative abundance of these insect pests and that time of harvest and storage duration affect the number and species abundance of such insect pests.

Fungi isolated from ginger samples consisting of *A. flavus*, *A. niger*, *F. oxysporium* and *Rhizopus* sp. and these have been reported to be associated with postharvest rot (Okigbo, 2005; Okigbo and Nwakammah, 2005; Fandohan et al., 2005). These fungal species observed must have been present in the atmosphere in the form of spores in the course of drying ginger rhizomes. Air is made up of many types of spores and other gases. The presence of these fungal species in ginger samples may be contaminants from the atmosphere since the ginger samples produced utilizable nutrients for the growth of the pathogens. Isolation of species of microflora across markets could also mean that some of these fungi were actually carried from same source to the different markets for storage and sales. According to Adebanjo and Shopeju (1993) mycoflora could be carried into the store from field as well as the air. The presence of *Aspergillus* and *Fusarium* species on the ginger samples pose a serious threat to ginger consumers. Associated with these fungal species is the production of aflatoxins and fumonins which are known to be carcinogenic to humans (Fakhoury and Woloshuk, 2001; Marasas, 1995). Adebanjo and Shopeju (1993) indicated that the presence of *A. flavus* on vegetables at harvest, during sun drying and in store need to always be investigated since they have been previously associated with aflotoxin. It is also likely that storage system of ginger with components such as time of harvest, type of storage, hygiene and insect infestation, interact and influence fungal infection. Similarly, it has been reported that fungal species occurred more abundantly in more humid months than in the drier period (Ekundayo, 1986). In Nigeria, Udoh et al. (2000) showed that insect infestation in maize was correlated with *Aspergillus* infection. Fandohan et al. (2005) have shown that insects, mainly Lepidoptera and Coleoptera play an important role in *Fusarium* infection and revealed a strong relationship between insect damage and *Fusarium* infection. By boring a channel, the insect creates an opening which constitutes a natural barrier for fungal growth, promoting easy spread of the fungi.

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