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SCREENING OF SELECTED PROPERTIES OF SOME PADDY RICE VARIETIES FOR THEIR RESISTANCE AGAINST *SITOTROGA CEREALELLA* (OLIVIER) ATTACK IN STORAGE

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ABSTRACT

The susceptibility to *Sitotroga cereallela* (Olivier) infestation in some paddy varieties was carried out in the Food Storage Technology Laboratory, Department of Biology, Federal University of Technology, Akure (FUTA) at ambient temperature and relative humidity. Twenty varieties of paddy *Orzya sativa* obtained from National Institute of Cereal Research, Badeggi, Niger State were screened for their susceptibility. The results were based on means of moth emergence, percent weight loss and developmental period after the completion of first generation under controlled laboratory conditions. It was found that none of the varieties was completely immuned to insect infestation. The result showed that Cisdane, FARO 36, FAROX-228-4-1-1, and BG 90/2 varieties were least susceptible while NERICA 1, WITA 4, FARO 12, IRAT 133 and ITA 230 were most susceptible to infestation by *S. cerealella.* NERICA 1 was the most susceptible variety of all the paddy rice varieties screened. With advances in biotechnology and plant breeding, it is possible to transfer desirable characters from resistant varieties in other to improve their resistance to post-harvest infestation by *Sitotroga cerealella.*

Key words: *Oryza sativa*, Susceptibility, *Sitotroga cerealella*, Developmental period

INTRODUCTION

Rice, *Oryza sativa* L. is a staple food crop that is of high demand by the world population and second to maize in terms of production quantity world over (FAO, 2010). It serves as major food source among Nigerians (Ashamo and Akinnawonu, 2012) because it is consumed in different forms which include fried rice, groundnut rice, rice paste ("tuwo shinkafa") among others.

Several challenges are encountered in rice cultivation, ranging from the insect attack, vertebrate pests, microbial infections and environmental inconsistencies both on the field and in the store. Insect attacks on rice especially in storage have always been the major concerns of scientists because it contributes significantly to both the quality and quantity loss. The major insect pests of rice include *Sitotroga cerealella, Sitophilus oryzae, S. zeamais, S. granarius, Rhyzopertha dominica* and stem borers including *Scirpophaga incertulas* and *S. innotata* (Sarwar, 2012, Ashamo and Akinnawonu, 2012).

Over the years, there has been almost total reliance on chemical insecticides for the control of a wide range of insect pests affecting rice in storage. The adverse effects posed by these chemical insecticides necessitated the search of other means of controlling the insect pests. Such adverse effects include pollution poisoning, residue accumulation, development of pest resistance and high cost of application (Akinneye and Ogungbite, 2013). Therefore, the challenge before the agricultural scientists today is the development insect resistant rice varieties that are capable of resistance to insect infestation. Insect resistant plants have the ability to withstand the effects of an insect by becoming resistant to its ill effects by means of genetic manipulation. Varieties that are consistently less infested and damaged by a particular species are called “resistant.” Painter (1951) defined plant resistance as “the relative amount of heritable qualities possessed by a plant which influence the ultimate degree of damage done by the insect. The objective of the study therefore was to screen twenty varieties of paddy rice for their resistance against *Sitotroga cerealella* attack in storage as this could bring about drastic reduction in the use of synthetic chemical insecticides.

MATERIALS AND METHODS

Insect culture

The *S. cerealella* adults used for this study were obtained from an existing culture in the Food Storage Technology Research laboratory of the Department of Biology, Federal University of Technology, Akure. The moths were reared on clean, uninfested paddy (FARO 52) obtained from Agricultural Development Project, Akure, Nigeria, in a 2L jars capped with a piece of muslin cloth which allowed ventilation but prevent entry or exit of moths, other insects, as well as extraneous materials. The jars were kept in insect cages, and the culture was maintained by consumed replacing grains with fresh, non-infested ones at ambient temperature of 28±2^{o}C and 75±5% relative humidity in the laboratory.

Source, characteristics and proximate composition of rice

The rice varieties screened were obtained from Badeggi, Niger State, Nigeria. They were disinfested by keeping them in deep freezer at -10˚C for one week and later air-dried. The moisture content was equilibrated to 12.5-13%. The length and the width were measured using the vernier caliper while the 100-seed weight was measured using the digital weighing balance. The California Bearing Ratio (CBR) compression machine was used in determining the seed coat hardness. The CBR compression machine (CON1TROSF, MOD. T105 MATR. 5071259, Milano, Italy) was regulated to zero. Ten grains were picked randomly from each of the varieties and each of the samples was placed on the beam of the machine. The bearing ratio (strength) value of each grain was read and multiplied by a constant (23.8N) to convert the value to Newton unit. Proximate compositions of each paddy variety were determined before and after the susceptibility experiment according to the standard method by AOAC (1990).

Determination of Susceptibility of rice varieties and developmental period of *S. cerealella*

Twenty grammes of paddy varieties were weighed into 100ml plastic container and replicated six times. Ten pairs of 0-24hr old adult male and female *S. cerealella* were introduced into the paddy varieties inside the containers. The insects were allowed to mate and oviposite for six days during which the insect laid eggs. On the 7th day of infestation, both dead and live moths were removed and discarded. Twenty days after infestation, the paddy varieties were checked daily for adult emergence. The number of adults that emerged was counted until no adult emergence was recorded for consecutive five days and the set up was left for another twenty days to allow for F_2 generation. Susceptibility index, developmental period in days and percentage weight loss were calculated after F_2 generation.

$$\text{Susceptibility index (S1)}\ \frac{InF_1}{DF_1}x100$$

Dobie (1974).

Where F_1 is the total number of first emerged adults and D is the median developmental period estimated as the time from the middle of oviposition to the emergence of 50% of F_1 generation in days. The twenty varieties were categorized on the basis of their susceptibility index into susceptibility, moderately susceptible and least susceptible according to the modified methods of Ajayi and Lale (2001).

Statistical analysis

All the data obtained were subjected to analysis of variance (ANOVA) using SPSS 16.0 software (SPSS, Inc. 2007). Means were separated using the New Duncan’s Multiple Range Test.

RESULTS

Characteristics and proximate composition of rice varieties

The physical characteristics of the different rice varieties are shown in Table 1. The grain lengths of the paddy varieties ranged from 8.2mm in TOX - 103 and ITA 321 to 10.2mm in ITA 230 and DE- GAULLE. Significant differences ($p < 0.05$) existed among the varieties. The grain width of the paddy varieties ranged from 2.0 mm in MAKALIOKA and IRAT 133 to 3.1mm in BG 90/2 and WITA 4 and it was significantly different ($p < 0.05$) from others . Length to width ratio of the paddy rice varieties ranged from 2.83mm in TOX 103 and ITA 231 to 3.58mm in IRAT 133 (p < or > 0.05). The 100- seed weight of the paddy rice varieties ranged from 2.37g in MAKALIOKA 823; IR-627-1-3-1-4-3-7, and IRAT 133 to 4.08 in DE-GAULLE and ITA 306 and it was significant ($p < 0.05$) from other varieties. The hardness of the paddy rice varieties ranged from 89.00N in MAKALIOKA 823 to 182.47N in ITA 306 and was significantly different ($p < 0.05$) from other varieties. Amylose content of the rice varieties ranged from 12.01% in MAKALIOKA 823 to 25.58% in FARO 30.

The proximate composition of the different paddy rice varieties are shown in Table 2. The moisture content of the paddy varieties varied considerably, ranging from 10.37% in FARO 36 to 11.56% in FAROX 228 – 4– 1 – 1($p < 0.05$). The crude protein content of the paddy varieties ranged from 5.03% in IRAT 133 to 10.26% in BG 79, both varieties were significantly different from others ($p < 0.05$). Fat content of paddy varieties ranged from 0.98% in WITA 4 to 2.68% in ITA 306 and TOS 103 and they were significantly different ($p < 0.05$) level from others. Carbohydrate contents in paddy rice varieties ranged between 47.82% in FARO 30 and 66.02% in TOS 103 and were significantly different from other varieties ($p < 0.05$). The ash content varied from 2.29% in BG 90/2 to 4.08% in NERICA 1.The mean ash values were significantly different from each other. The mean values for fibre ranged from 18.36% in FARO 12 to 26.35% in DE- GAULLE and were significantly different from others ($p < 0.05$).

Susceptibility of rice varieties and emergence of *Sitotroga cerealella*

The developmental period, susceptibility index, adult emergence of *S. cerealella* and percentage weight loss in different paddy rice varieties subjected to infestation by *S. cerealella* are presented in Table 3. Developmental periods ranged from 28.00 (days) in WITA 4 to 31.67 days in Sipi 692033 which were significantly different ($p < 0.05$) from each other. Susceptibility index (SI) in paddy varieties ranged from 2.10 in BG 90/2 to 11.94 in NERICA1 and were significantly different from each other. Adult emergence in the different paddy varieties varied from 2.00 in BG 90/2 to 16.00 in ITA 230, with significant differences ($p < 0.05$) existing among the varieties. On the basis of Susceptibility index (SI), the different paddy varieties were categorized into three which are; most susceptible (SI from 8.06 - 11.94), moderately susceptible (SI from 5.01 - 7.96) and least susceptible (SI from 2.10 – 4.39). The percentage weight loss in the different varieties ranged from 0.7 in ITA 306 to 10.05 in NERICA 1 and were significantly different from each other and other varieties ($p < 0.05$)

Table 1: Physical characteristics of paddy rice varieties

S/N	Varieties	Length(mm)	Width(mm)	L.W. ratio	100 - seed weight(g)	Seed Hardness(N)	Amylose content (g/100g)
1	BG 79	9.40 ± 0.04^{c}	2.80 ± 0.01^{b}	3.36	2.60 ± 0.06^{bc}	134.87 ± 0.06^{e}	14.31
2	MAKALIOKA 823	9.30 ± 0.06^{c}	2.60 ± 0.01^{a}	3.56	2.37 ± 0.33^{e}	89.00 ± 0.18^{a}	12.01
3	FARO 12	10.00 ± 0.06^{e}	3.00 ± 0.01^{d}	3.33	3.13 ± 0.33^{e}	166.67 ± 0.30^{h}	14.78
4	IR-627-1-3-1-4-3-7	9.40 ± 0.03^{c}	$2.9\ 0 \pm 0.01^{c}$	3.24	2.37 ± 0.07^{d}	114.53 ± 0.07^{c}	17.10
5	DE- GAULLE	10.20 ± 0.04^{e}	3.00 ± 0.01^{d}	3.40	3.37 ± 0.03^{e}	142.80 ± 0.20^{e}	18.25
6	TOS-103	8.20 ± 0.04^{a}	2.90 ± 0.01^{c}	2.83	2.40 ± 0.06^{a}	114.73 ± 0.16^{c}	13.73
7	BG 90/2	9.00 ± 0.06^{b}	3.10 ± 0.01^{e}	2.90	3.10 ± 0.00^{e}	150.73 ± 0.07^{f}	18.14
8	FARO 30	9.30 ± 0.03^{c}	3.00 ± 0.01^{d}	3.10	2.67 ± 0.03^{cd}	158.67 ± 0.03^{g}	25.58
9	FAROX 228 – 4– 1 – 1	9.20 ± 0.01^{b}	2.90 ± 0.01^{c}	3.17	2.50 ± 0.05^{ab}	126.67 ± 0.07^{d}	14.75
10	FARO 36	9.70 ± 0.03^{d}	2.80 ± 0.01^{b}	3.46	3.03 ± 0.03^{ebc}	128.00 ± 0.11^{d}	25.04
11	ITA 306	9.40 ± 0.04^{c}	2.80 ± 0.01^{b}	3.36	2.60 ± 0.05^{bca}	182.47 ± 0.13^{i}	14.35
12	IRAT 133	9.30 ± 0.06^{c}	2.60 ± 0.01^{a}	3.58	2.37 ± 0.07^{a}	142.80 ± 0.01^{e}	14.68
13	FARO 43	9.40 ± 0.03^{c}	2.90 ± 0.01^{c}	3.24	2.77 ± 0.07^{d}	95.20 ± 0.12^{b}	15.14
14	Sipi 692033	10.00 ± 0.06^{e}	3.00 ± 0.00^{d}	3.33	3.13 ± 0.33^{e}	158.67 ± 0.08^{g}	25.49
15	ITA 230	10.20 ± 0.04^{e}	3.00 ± 0.01^{d}	3.40	3.37 ± 0.03^{e}	134.87 ± 0.06^{e}	24.32
16	Cisadane	9.70 ± 0.03^{d}	2.80 ± 0.01^{b}	3.16	3.03 ± 0.03^{e}	119.00 ± 0.09^{c}	15.12
17	WITA 4	9.00 ± 0.06^{b}	3.10 ± 0.01^{e}	2.90	3.10 ± 0.00^{e}	134.87 ± 0.06^{e}	14.86
18	ITA 321	8.20 ± 0.04^{a}	2.90 ± 0.01^{c}	2.83	2.40 ± 0.06^{a}	142.60 ± 0.03^{e}	14.89
19	FARO 54	9.30 ± 0.01^{c}	3.00 ± 0.01^{d}	3.10	2.67 ± 0.03^{cd}	134.87 ± 0.03^{e}	15.11
20	NERICA 1	9.20 ± 0.01^{b}	2.90 ± 0.01^{c}	3.17	2.50 ± 0.06^{ab}	126.93 ± 0.11^{d}	15.01

Each value is the mean of ± standard error of 6 replicates. Mean followed by the same letters within the same column are not significantly (P > 0.05) different from each other using New Duncan's Multiple Range Test.

Table 2: Proximate composition of paddy rice varieties

S/N	Variety	Moisture content (%)	Crude protein (%)	Fat content (%)	Crude fibre (%)	Ash content (%)	Carbohydrate (%)
1	BG 79	10.80 ± 0.12^{bc}	10.26 ± 0.12^{g}	1.75 ± 0.03^{c}	20.11 ± 0.06^{b}	3.80 ± 0.06^{e}	53.28 ± 0.03^{f}
2	MAKALIOKA 823	10.54 ± 0.02^{ab}	9.22 ± 0.00^{f}	2.13 ± 0.02^{e}	21.34 ± 0.02^{d}	2.44 ± 0.06^{a}	54.33 ± 0.02^{g}
3	FARO 12	10.68 ± 0.05^{bc}	10.59 ± 0.06^{h}	1.68 ± 0.05^{c}	18.36 ± 0.03^{a}	2.82 ± 0.01^{b}	55.87 ± 0.01^{h}
4	IR-627-1-3-1-4-3-7	10.73 ± 0.12^{bc}	8.82 ± 0.01^{e}	2.60 ± 0.06^{f}	20.70 ± 0.12^{c}	3.13 ± 0.02^{c}	54.02 ± 0.02^{fg}
5	DE- GAULLE	11.19 ± 0.11^{c}	8.31 ± 0.12^{d}	1.85 ± 0.03^{d}	26.35 ± 0.03^{h}	2.65 ± 0.03^{b}	49.65 ± 0.02^{b}
6	TOS-103	10.88 ± 0.12^{cd}	6.08 ± 0.05^{b}	2.68 ± 0.01^{f}	21.47 ± 0.01^{d}	2.87 ± 0.01^{b}	66.02 ± 0.03^{i}
7	BG 90/2	11.10 ± 0.03^{c}	8.67 ± 0.04^{de}	1.37 ± 0.04^{b}	20.11 ± 0.01^{a}	2.29 ± 0.01^{a}	56.52 ± 0.01^{i}
8	FARO 30	12.86 ± 0.03^{g}	8.51 ± 0.06^{d}	1.74 ± 0.01^{c}	25.96 ± 0.03^{g}	3.11 ± 0.01^{c}	47.82 ± 0.07^{a}
9	FAROX 228 – 4– 1 – 1	11.56 ± 0.12^{f}	7.03 ± 0.02^{c}	1.16 ± 0.03^{a}	26.08 ± 0.02^{f}	3.38 ± 0.02^{d}	50.79 ± 0.03^{c}
10	FARO 36	10.37 ± 0.06^{a}	7.15 ± 0.03^{d}	1.72 ± 0.01^{c}	22.39 ± 0.02^{d}	2.86 ± 0.02^{b}	55.60 ± 0.02^{e}
11	ITA 306	10.88 ± 0.01^{bc}	6.08 ± 0.01^{c}	2.68 ± 0.01^{f}	21.47 ± 0.02^{c}	2.87 ± 0.01^{b}	56.02 ± 0.01^{e}
12	IRAT 133	10.91 ± 0.02^{c}	5.03 ± 0.01^{a}	1.71 ± 0.01^{c}	24.89 ± 0.03^{f}	3.06 ± 0.01^{c}	54.40 ± 0.01^{d}
13	FARO 43	11.10 ± 0.01^{d}	8.49 ± 0.01^{e}	1.21 ± 0.00^{b}	19.50 ± 0.01^{b}	3.44 ± 0.01^{d}	56.26 ± 0.03^{e}
14	Sipi 692033	11.26 ± 0.01^{e}	6.32 ± 0.01^{c}	1.79 ± 0.01^{d}	20.88 ± 0.12^{bc}	3.16 ± 0.01^{c}	56.09 ± 0.01^{e}
15	ITA 230	10.74 ± 0.01^{b}	9.15 ± 0.01^{f}	2.30 ± 0.01^{f}	25.48 ± 0.03^{f}	2.49 ± 0.01^{b}	49.86 ± 0.04^{b}
16	Cisadane	11.03 ± 0.01^{d}	7.31 ± 0.01^{d}	2.09 ± 0.01^{e}	24.61 ± 0.06^{f}	5.01 ± 0.01^{g}	49.95 ± 0.06^{b}
17	WITA 4	10.87 ± 0.01^{bc}	5.70 ± 0.01^{b}	1.54 ± 0.01^{c}	23.99 ± 0.01^{e}	3.82 ± 0.01^{e}	54.08 ± 0.03^{d}
18	ITA 321	11.00 ± 0.01^{d}	7.59 ± 0.00^{d}	1.86 ± 0.01^{d}	$23.60 \pm o.06^{e}$	2.87 ± 0.01^{b}	53.08 ± 0.06^{d}
19	FARO 54	10.82 ± 0.01^{bc}	10.19 ± 0.01^{g}	0.98 ± 0.01^{a}	24.15 ± 0.02^{f}	2.56 ± 0.01^{b}	51.30 ± 0.10^{c}
20	NERICA 1	10.96 ± 0.01^{c}	9.32 ± 0.01^{f}	1.92 ± 0.10^{d}	23.12 ± 0.03^{e}	4.08 ± 0.01^{f}	50.60 ± 0.07^{bc}

Each value is the mean of ± standard error of 6 replicates. Mean followed by the same letters within the same column are not significantly (P > 0.05) different from each other using New Duncan's Multiple Range Test.

Table 3: Developmental period, susceptibility index, adult emergence of *S. cerealella* and percentage weight loss in paddy rice varieties.

S/N	Varieties	Developmental Period (days)	Adult Emergence F_1	Susceptibility Index (S1)	Classification	Percentage Weight loss (g)
1	Cisadane	29.33 ± 0.33^{ab}	3.00 ± 0.08^{a}	2.96 ± 1.90^{a}	Least susceptible	3.97 ± 0.29^{de}
2	FARO 36	28.00 ± 0.58^{a}	4.00 ± 1.73^{ab}	4.39 ± 2.01^{b}	Least susceptible	2.78 ± 2.33^{c}
3	FAROX 228 – 4– 1 – 1	28.00 ± 0.58^{a}	4.00 ± 2.00^{ab}	4.10 ± 1.67^{b}	Least susceptible	3.33 ± 3.00^{d}
4	BG 90/2	28.33 ± 0.33^{a}	2.00 ± 0.58^{a}	2.10 ± 1.18^{a}	Least susceptible	0.7 ± 0.99^{a}
5	ITA 306	30.00 ± 1.15^{b}	8.33 ± 2.03^{c}	6.83 ± 0.74^{c}	Moderately susceptible	4.67 ± 0.79^{e}
6	Sipi 692033	31.67 ± 0.88^{b}	4.67 ± 1.76^{a}	5.01 ± 1.59^{a}	Moderately susceptible	0.88 ± 0.19^{a}
7	IR-627-1-3-1-4-3-7	29.00 ± 0.58^{ab}	7.00 ± 1.15^{b}	6.61 ± 0.53^{c}	Moderately susceptible	3.11 ± 1.33^{d}
8	DE- GAULLE	28.67 ± 1.20^{a}	6.33 ± 1.45^{b}	6.17 ± 0.77^{c}	Moderately susceptible	3.15 ± 1.79^{d}
9	TOS-103	28.00 ± 0.58^{a}	7.67 ± 1.86^{b}	6.94 ± 1.24^{c}	Moderately susceptible	2.42 ± 0.69^{c}
10	FARO 30	28.00 ± 0.58^{a}	7.33 ± 2.33^{b}	6.54 ± 1.33^{c}	Moderately susceptible	5.70 ± 2.29^{f}
11	MAKALIOKA 823	28.33 ± 0.67^{a}	7.33 ± 0.88^{b}	7.96 ± 0.85^{d}	Moderately susceptible	2.43 ± 0.99^{c}
12	ITA 321	30.00 ± 0.58^{b}	8.00 ± 2.08^{c}	6.62 ± 0.96^{c}	Moderately susceptible	2.46 ± 0.89^{c}
13	FARO 54	32.33 ± 1.45^{c}	7.00 ± 3.00^{b}	6.43 ± 1.05^{c}	Moderately susceptible	1.50 ± 2.19^{bc}
14	BG 79	31.00 ± 0.58^{bc}	14.33 ± 1.45^{d}	7.02 ± 1.43^{d}	Moderately susceptible	3.70 ± 1.29^{d}
15	FARO 43	29.00 ± 0.58^{ab}	2.67 ± 0.67^{a}	5.35 ± 1.04^{bc}	Moderately susceptible	4.32 ± 0.77^{e}
						10.29 ± 0.29^{g}
16	NERICA 1	29.33 ± 0.33^{ab}	33.33 ± 7.26^{f}	11.94 ± 0.08^{f}	Most susceptible	3.97 ± 0.29^{de}
17	WITA 4	28.00 ± 0.00^{a}	8.00 ± 3.60^{c}	9.44 ± 0.99^{e}	Most susceptible	3.06 ± 1.09^{d}
18	FARO 12	27.00 ± 0.58^{a}	9.67 ± 2.67^{c}	8.06 ± 0.98^{e}	Most susceptible	2.45 ± 0.90^{c}
19	IRAT 133	30.00 ± 0.58^{b}	14.67 ± 1.20^{d}	8.93 ± 0.27^{e}	Most susceptible	2.95 ± 0.89^{c}
20	ITA 230	28.00 ± 0.58^{a}	16.00 ± 0.57^{e}	9.20 ± 0.49^{cd}	Most susceptible	10.20 ± 0.29^{g}

Each value is the mean of ± standard error of 6 replicates. Mean followed by the same letters within the same column are not significantly ($P > 0.05$) different from each other using New Duncan's Multiple Range Test.

DISCUSSION

The results show that Cisdane, FARO 36, FAROX-228-4-1-1, BG 90/2 varieties were least susceptible. Moderately susceptible varieties were IR-627-1-3-1-4-3-7, Sipi 692033, DE-GAULLE, TOS-103, FARO 30, MAKALIOKA 823, ITA 321, FARO 54, BG 79 and FARO 43 while NERICA 1, WITA 4, FARO 12, IRAT 133 and ITA 230 were most susceptible to infestation by *Sitotroga cerealella*. NERICA 1 was the most susceptible variety of all the paddy varieties because it had highest number of emerged adults, weight loss and a short developmental period. This might be as a result of differences in their compositions and genetic make-up. It is produce by a cross between WAB 56 – 104 and CG 14. Consoli and Amaral (1995) reared *S. cereallela* on five corn genotypes and found out that the lowest survival rate from egg to adult was among the insect reared on SUO_2 and Sh_2 and may be related to the high amlylose content in these varieties , however amylose content in the different paddy varieties have no significant effect on their susceptibility. Hameed *et al.* (1984reported that the moisture contents had significant effect on the development of stored grain insects. Almeida and Murta (1995), who reported that moisture contents of grains were significantly decreased by infestation. Slight variation in the susceptibility of varieties was found due to their chemical nature. These results are in conformity with the previous research work of Khattak and Shafique (1981). Protein, fat, carbohydrate contents are also responsible for the susceptibility in addition to the main factors as weight loss, percent damage. It was recorded that there was positive correlation between the weight loss and protein contents of the grain. The results of the present study are not in conformity with the work of Mohammad *et al.* (1988) in which resistant varieties were reported to have high protein contents. This variation may be due to the inherent nature of their varieties.

The differences in the sizes and amylose content in the paddy varieties in the present study does not have any effect on their susceptibility. Rao and Sharma (2003) further reported that protein content in wheat had little role in resistance.

According to the work of Ashamo and Khanna (2006a), susceptibility to *S. cerealella* in sorghum varieties was more likely to be due to differences in their biochemical characteristics (lipids, protein, sugars starch etc) since susceptibility in the sorghum varieties were not dependent on the seed hardness. Adedire *et al.* (2011) reported that maize cultivars with high kernel hardness which had low percentage grain damage however, in the present study seed hardness did not contribute to susceptibility of paddy rice varieties. This is in agreement with the findings in Ashamo and Khanna (2007) in which there was no significant correlation between susceptibility and seed hardness of wheat varieties to *S. cerealella*. Ashamo and Khanna (2007) concluded that susceptibility/resistance to *S. cerealella* was perhaps due mainly to differences in their biochemical characteristics. According to the work of Demissie *et al*. (2015) who worked on different varieties of maize infested with *S. cerealella*, it is important to breed maize variety considered on the low ash, low amylose and high phenolic content besides other morphological and physical characteristics in order to get maize variety which is resistant to *S. cerealella*.

In a related work by Ashamo and Khanna (2007) on wheat, it was observed that differences in the physical characteristics (length, width, weight, weight of seeds and seed hardness does not correlate with differences in susceptibility observed in their study. However, Ashamo and Khanna (2006a) reported that small sized - seeds of sorghum tend to be less susceptible than the larger- sized seeds

Seed size according to Dharmasena and Subasinghe (1986) had been shown to influence to influence infestation by insect pests as large grains provide more surface area for ovipositon and larva development than small size grains. In the present study, IRAT 133 which had the highest length to width ratio of the grain size was also among the most susceptible varieties while TOS 103 and IRAT 321 that had the lowest values of length to width ratio were moderately susceptible.

CONCLUSION

From this study, Cisdane, FARO 36, FAROX-228-4-1-1, and BG 90/2 varieties were least susceptible while NERICA 1, WITA 4, FARO 12, IRAT 133 and ITA 230 were most susceptible to infestation by *S. cerealella*. NERICA 1 was the most susceptible variety of all the paddy varieties screened. With available recent advances in biotechnology and plant breeding, it is practicable to transfer desirable characters from resistant varieties to susceptible varieties in other to improve their resistance to post-harvest infestation by *Sitotroga cerealella*. Alternatively, farmers can be informed through the agricultural extension officers about these paddy rice varieties; IR-627-1-3-1-4-3-7, Sipi 692033, DE- GAULLE, TOS-103, FARO 30, MAKALIOKA 823, ITA 321, FARO 54, BG 79 and FARO 43 that are moderately susceptible to *S. cerealella* and advised to cultivate them. This will go a long way in ensuring food security in Nigeria and greatly reduces losses accounted for in most developing world due to post harvest infestation by stored product pests.

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