



The Influence of Food Type on the Response of *Sitophilus zeamais* (Motschulsky) (*Coleoptera: Curculionidae*) to Cypermethrin

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Abstract

The effect of food type on the response of maize weevil, *Sitophilus zeamais* (Motschulsky) to cypermethrin was investigated. Weevils were reared on maize, wheat and sorghum at ambient temperature ($28\pm 2^{\circ}\text{C}$) and relative humidity ($75\pm 6\%$). Twenty grams of each food type was doused with one millilitre of different concentrations (0.00001-0.1%) of cypermethrin. Twenty emerged weevils from each food were then exposed to each pre-treated food type. Two control experiments were also set up (one with neither cypermethrin nor methanol and the other with only methanol). The mortality was assessed after 6, 12, 18 and 24 hours post-treatment. Weevil mortality varied with host food, cypermethrin concentration and exposure time. All weevils exposed to cypermethrin treated maize and sorghum grains, respectively exhibited complete (100%) mortality at 0.1% after 24 hours' exposure while there was incomplete mortality (96.88%) in weevils exposed to 0.1% cypermethrin after 24 hours' exposure. The lethal concentration values also showed that susceptibility of *S. zeamais* to cypermethrin was least in wheat-reared weevils (LC_{75} : 0.052 g ml⁻¹ and LC_{95} : 275.890 g ml⁻¹) while highest susceptibility was observed in maize-reared weevils (LC_{75} : 0.009g ml⁻¹; LC_{95} : 0.813 g ml⁻¹). The sorghum-reared weevils however showed the median susceptibility (LC_{75} : 0.018g ml⁻¹; LC_{95} : 106.530 g ml⁻¹) to this pyrethroid. Also, irrespective of the host food, there was significant reduction and inhibition ($p < 0.05$) in the adult emergence and developmental period of *S. zeamais* in treated grains when compared to that of untreated and solvent-treated grains. Similarly, weight loss in the treated maize grains was also significantly lower ($p < 0.05$) than that of untreated and solvent-treated grains. This study reveals that the host food on which weevil developed influenced considerably the degree of tolerance to cypermethrin. It could therefore be recommended that crop merchants, peasant farmers and pest control managers should be mindful of host food on which *S. zeamais* is found when controlling them using cypermethrin insecticide. This will help to prevent the problem of pest resistance that is currently associated with other synthetic insecticides.

Keywords: Cypermethrin, *Sitophilus zeamais*, Weight loss, Adult emergence, Lethal concentration.

INTRODUCTION

The maize weevil, *Sitophilus zeamais* (Motschulsky) is one of most destructive and infamous primary post-harvest pest of cereal

crops. Although this pest is principally found associated with maize grains (*Zea mays*); it is also capable of developing on a wide range of cereal crops like sorghum (*Sorghum bicolor*) and wheat (*Triticum* sp) grains. Both the larva and adult stage are the most destructive stage due to their feeding activity. The weevil is highly

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cosmopolitan due to its wide occurrence in all continent of the world, particularly in Africa (Champ and Dyte, 1976; Evans, 1985). Heavy infestation by this weevil may result to reduction in weight, aesthetic value, nutritional quality and viability of the affected grains, depending on the cereal host and method of storage (Ofuya and Lale, 2001). Several control measures of varying efficacy have been introduced to reduce the various threat associated with this weevil, including the use of botanicals, hermetic storage, use of resistant seeds, use of low temperature, solar radiation, biological control and chemical control among others.

In Nigeria, the use of chemical insecticide has gained prominence over other afore-mentioned methods of control, especially in large scale storage. They are being used mainly to control insect pest infestation by farmers and crop merchants on the field and during storage respectively. Consequently, chemical pesticides like organophosphate, carbamates and organochlorines have played a key role in the management of several insect pests infesting food grains (Chedi and Aliyu, 2010). The overreliance on some of these chemical insecticides, over the years coupled with widespread public concern over insecticide residues in foods, and their negative impacts on the environment, human health (Park *et al.*, 2003) as well as emergence of resistant insects (Odeyemi *et al.*, 2006; Booth *et al.*, 2007; Gbaye *et al.*, 2016) have constantly given impetus for the development of new approaches in insect pest management.

The use of insecticides derived from plant origin has been touted as one of the suitable alternatives to synthetic insecticides in insect pest management. This has led to the grouping of botanical products being used for insect pest control into four different types, namely; pyrethrum, rotenone, neem, and essential oils

(Isman, 2006). But, myriad of problems, such as instability in the environment, disagreeable odour and inconsistent availability associated with these botanical products, have led to the production of their synthetic derivatives. For instance, pyrethroids are known to have been synthesized based on the structure of pyrethrum, a natural insecticide which is contained in *Chrysanthemum* flowers, but with higher biological activity and stability than its natural model (Gosselin *et al.*, 1984). Its usage has increased tremendously in recent years as organophosphates, carbamates and organo-chlorines are being phased out in many part of the world (Lopez and Fernández-Bolaños, 2011).

Some of the common examples of known pyrethroids include deltamethrin, permethrin, fenvalerate, sumithrin, cypermethrin, among others (Desmarchelier, 1994; Zettler *et al.*, 1997; Gbaye *et al.*, 2012; Perveen and Khan, 2014). Of all these compounds, cypermethrin is one of the commonest pyrethroids being used on a wide scale insect pest control (Lopez and Fernández-Bolaños, 2011). It acts as a stomach and contact insecticide against insect pest in cotton, cereals, vegetables and fruit plantations as well as in public health and animal husbandry (Singh *et al.*, 2012; Andrić *et al.*, 2014). Most studies on cypermethrin have been focused on their residual activity, effectiveness, toxicity to humans and comparison with other methods of control (Pascual and Peris, 1992; Amer *et al.*, 1993; Andrić *et al.*, 2014). However, several authors have earlier reported that the type of food on which an insect develop affect its toxicity to insecticides (Liang *et al.*, 2007; Gbaye *et al.*, 2011; Oyeniyi *et al.*, 2015a, 2015b). There is however a dearth of studies on the effect of host food on the response of *S. zeamais* to cypermethrin. This study therefore investigates the influence of host food type on the insecticidal response of *S. zeamais* to cypermethrin.

MATERIALS AND METHODS

Sourcing of Cereals

White cultivars of maize and sorghum were purchased from Oba market, Ondo state while the wheat grains were sourced from a retail shop in Apatapiti, Federal University of Technology, South gate, Akure, Ondo state, Nigeria. The grains were sorted to separate damaged grains and debris from wholesome grains. The wholesome grains were disinfected in the freezer at -10°C for 3 weeks and allowed to equilibrate in the laboratory for 2-3 days to prevent mouldiness (Oyeniya *et al.*, 2015a).

Insect Culture

A laboratory culture of *S. zeamais* that has been maintained on maize grains for several generations was obtained from Biology Research Laboratory, Federal University of Technology, Akure, Ondo state, Nigeria. The starter culture that has neither been exposed to synthetic nor botanical insecticides was reared on disinfected maize, wheat and sorghum for two generations, to eliminate maternally inherited dietary effect (Gbaye and Holloway, 2011).

Preparation of Cypermethrin

Stock solution of 0.2% was prepared by pipetting 0.02 ml of cypermethrin into 9.98 ml of methanol. The cypermethrin (Cypertrap, 10 % EC) used for the experiment was obtained from an Agrochemical store in Akure, Ondo state, Nigeria. Thereafter, a serial dilution of different concentrations of 0.1%, 0.01%, 0.001%, 0.0001%, and 0.00001% was made from the stock solution.

Contact Toxicity Test

Twenty grams (20 g) of each food (maize, wheat and sorghum) was weighed using Metler beam weighing balance into 170 ml plastic containers. One millilitre (1 ml) of each concentration was added to each food and mixed thoroughly by

shaking vigorously. Two control experiments were made: one with only methanol (Control A) and the other with no cypermethrin and methanol (Control B). Twenty adult *S. zeamais* emerging from each food were then introduced into each pre-labelled plastic containers containing corresponding doused grains. Each treatment was replicated four times and adult mortality was recorded after 6, 12, 18 and 24 hours' post-treatment.

Determination of Adult Emergence, %IR and Weight loss of grains

All insects were removed after 24 hours from each grain and the experiment was left for 42 days to allow for emergence of F₁ generation. The number of adult that emerged was counted and percentage Inhibition Rate (%IR) in adult emergence was calculated using the method described by Taponjju *et al.* (2002).

$$\% \text{ IR} = \frac{C_n - T_n}{C_n} \times \frac{100}{1}$$

Where C_n is the number of insects that emerged in the control treatment and T_n is the number of adult insects that emerged in the treated grains.

The weight loss of stored grains was also calculated using the method described by Ogungbite and Oyeniya (2014).

% Weight loss

$$= \frac{\text{Initial weight} - \text{final weight}}{\text{Initial weight}} \times 100$$

Statistical Analysis

All data were subjected to analysis of variance (ANOVA) and the treatment means were separated using Tukey's Test at $\alpha = 0.05$. Data on adult mortality were also subjected to probit analysis to determine the concentration of cypermethrin required to achieve 75% (LC₇₅) and

95% (LC_{95}) mortality in maize, wheat and sorghum reared weevils (Finney, 1971). All analyses were done using Statistical Package for Social Sciences (SPSS) 17.0 software package.

RESULTS

Response of *S. zeamais* reared on three foods (maize, wheat and sorghum) to cypermethrin

Tables 1-3 show the response of *S. zeamais* reared on maize, wheat and sorghum to different concentrations of cypermethrin. Regardless of the host food, weevil mortality increased with increase in exposure time and concentration of

cypermethrin. There was also a significant effect ($p < 0.0001$) of exposure time on the mortality of *S. zeamais* irrespective of the host food. Similarly, mortality values in treated weevils were significantly higher than that of both solvent and ordinary control regardless of the exposure time and host food. Highest mortality which range from 68.75 to 100% was observed in maize-reared weevils when compared to their counterpart reared on wheat (45.31-96.88%) and sorghum (51.56-100%) grains after 24 hours' post-treatment.

Table 1: Effect of Cypermethrin on the mortality (Mean \pm S,E) of *Sitophilus zeamais* reared on maize grains

Concentration (%)	Exposure time			
	6	12	18	24
0.00001	23.44 \pm 3.93 ^b	21.88 \pm 4.03 ^b	35.94 \pm 1.89 ^b	68.75 \pm 0.00 ^b
0.0001	29.69 \pm 1.33 ^{bc}	34.38 \pm 1.25 ^{bc}	46.88 \pm 1.83 ^{bc}	73.44 \pm 1.56 ^b
0.001	50.00 \pm 0.00 ^{cd}	67.19 \pm 1.47 ^c	68.75 \pm 1.19 ^{cd}	93.75 \pm 0.00 ^c
0.01	60.94 \pm 1.65 ^d	68.73 \pm 2.55 ^c	87.50 \pm 2.08 ^d	95.31 \pm 1.56 ^{cd}
0.1	62.50 \pm 2.90 ^d	90.63 \pm 3.12 ^d	98.44 \pm 1.56 ^d	100.00 \pm 0.00 ^d
Control A	0.00 \pm 0.00 ^a	0.00 \pm 0.00 ^a	1.56 \pm 0.00 ^a	1.56 \pm 0.00 ^a
Control B	0.00 \pm 0.00 ^a			

Mean values followed by the same letter(s) are not significantly different ($P > 0.05$) by Tukey's Test. Control A: control with only methanol; Control B: control with neither cypermethrin nor methanol; S.E: Standard Error

Table 2: Effect of Cypermethrin on the mortality (Mean \pm S,E) of *Sitophilus zeamais* reared on wheat grains

Concentration (%)	Exposure time (Hours)			
	6	12	18	24
0.00001	37.50 \pm 1.12 ^b	37.50 \pm 1.12 ^b	45.31 \pm 1.10 ^b	45.41 \pm 1.10 ^b
0.0001	40.63 \pm 1.85 ^b	54.69 \pm 1.23 ^c	71.88 \pm 1.98 ^c	73.88 \pm 1.98 ^c
0.001	54.69 \pm 1.23 ^b	57.81 \pm 0.32 ^{cd}	81.25 \pm 0.46 ^{cd}	84.38 \pm 1.62 ^{cd}
0.01	50.00 \pm 3.75 ^{bc}	57.81 \pm 0.32 ^{cd}	84.38 \pm 1.62 ^{cd}	87.50 \pm 2.84 ^{dc}
0.1	76.56 \pm 1.18 ^c	84.38 \pm 1.62 ^d	96.88 \pm 3.12 ^d	96.88 \pm 1.21 ^{dc}
Control A	0.00 \pm 0.00 ^a	0.00 \pm 0.00 ^a	1.56 \pm 0.00 ^a	1.56 \pm 0.00 ^a
Control B	0.00 \pm 0.00 ^a			

Mean values followed by the same letter(s) are not significantly different ($P > 0.05$) by Tukey's Test. Control A: control with only methanol; Control B: control with neither cypermethrin nor methanol; S.E: Standard Error

Table 3: Effect of Cypermethrin on the mortality (Mean±S.E) of *Sitophilus zeamais* reared on sorghum grains

Concentration (%)	Exposure time (Hours)			
	6	12	18	24
0.00001	37.50±0.52 ^b	43.75± 1.25 ^b	50.00±1.65 ^b	51.56± 3.10 ^b
0.0001	43.75±1.25 ^b	59.38±2.26 ^c	62.50± 1.69 ^{bc}	70.31± 0.63 ^c
0.001	48.13±1.22 ^b	59.38±0.43 ^c	70.31±1.63 ^c	78.13±10.67 ^{cd}
0.01	48.44±0.32 ^b	60.94±1.06 ^c	90.62±3.41 ^{cd}	99.50±0.50 ^d
0.1	54.69±1.79 ^{bc}	90.63±2.37 ^d	98.44±1.54 ^d	100.00±0.00 ^d
Control A	0.50±0.00 ^a	1.00±0.57 ^a	2.56±1.31 ^a	2.56±1.31 ^a
Control B	0.00±0.00 ^a	0.00±0.00 ^a	0.00±0.00 ^a	0.00±0.00 ^a

Effect of host food type on the Lethal Concentrations (LC₇₅ and LC₉₅) (g ml⁻¹) of Cypermethrin to *S. zeamais* after 12 hours' post-treatment

Table 4 shows the effect of host food on the Lethal Concentrations (LC₇₅ and LC₉₅) (g ml⁻¹) of cypermethrin on *S. zeamais* after 12 hours' post-treatment. Positive slope of regression showed that mortality increased with increase in concentration of cypermethrin irrespective of the host food. The highest LC₇₅ and LC₉₅ values was observed for *S. zeamais* reared on wheat grains (LC₇₅:0.052g ml⁻¹; LC₉₅: 275.890g ml⁻¹) and this was followed by those reared on sorghum (LC₇₅: 0.018g ml⁻¹; LC₉₅: 106.530 g ml⁻¹) grains. Their counterpart reared on maize grains required the least lethal concentration (LC₇₅: 0.009 g ml⁻¹; LC₉₅: 0.813 g ml⁻¹). Weevils reared on wheat and sorghum grains were 5 and 2 times more tolerant of cypermethrin respectively, than their counterpart reared on maize grains using the LC₇₅ values. Using the LC₉₅ values, wheat and sorghum reared weevils were

224 and 131 times respectively, more tolerant of cypermethrin, than their counterpart reared on maize grains.

Effect of host food type on the emergence and percentage inhibition rate (%IR) of *S. zeamais* in cypermethrin treated grains

Table 5 displays the number of *S. zeamais* that emerged from treated maize, wheat and sorghum grains. Adult emergence decreased with increasing concentration of cypermethrin irrespective of the food host type. Significantly lower (p<0.05) number of *S. zeamais* emerged from all the insecticide treated grains when compared to weevil's emergence on solvent control and untreated grains. There was no significant difference (p>0.05) in the adult emergence of weevils on treated sorghum grains. However, adult emergence on treated maize (6.00) and wheat (6.25) grains at the highest experimental concentration (0.1%) was significantly lower than that of their counterpart on maize (20.75) and

Table 4: Effect of host food on the Lethal Concentrations (LC₇₅ and LC₉₅) (g ml⁻¹) of Cypermethrin against *Sitophilus zeamais* at 12 hours post-treatment

Host Food	Slope (±S.E)	χ ²	LC ₇₅ (95% FL)	LC ₉₅ (95% FL)
Maize	0.49 (±0.02)	383.35	0.009 (0.002-0.141)	0.813 (0.068-1.558)
Wheat	0.26 (±0.02)	442.51	0.052 (0.003-0.101)	275.890 (0.598-551.182)
Sorghum	0.26 (±0.02)	366.56	0.018 (0.001-0.035)	106.530 (0.406-212.654)

χ²: Chi-square; LC: Lethal concentration; FL: Fiducial limits; S.E: Standard Error; Values in parenthesis represents 95% Fiducial limits

Table 5: Number of adult emergence of *S. zeamais* from three host foods

Concentration (%)	Host food		
	Maize	Wheat	Sorghum
0.00001	20.75±1.14 ^b	17.25±0.34 ^b	22.75±0.79 ^{ab}
0.0001	18.50±0.56 ^b	11.50±0.57 ^{ab}	20.25±1.18 ^{ab}
0.001	12.50±0.53 ^{ab}	9.25±0.42 ^{ab}	17.00±0.70 ^{ab}
0.01	8.00±0.64 ^{ab}	8.75±0.591 ^{ab}	15.25±0.82 ^a
0.1	6.00±0.57 ^a	6.25±0.47 ^a	9.50±0.66 ^a
Control A	27.75±0.65 ^c	26.75±0.312 ^c	97.50±0.39 ^c
Control B	29.75±0.44 ^c	31.25±0.83 ^c	102.25±1.57 ^c

Mean values followed by the same letter(s) are not significantly different ($P>0.05$) by Tukey's Test. Control A: control with only methanol; Control B: control with neither cypermethrin nor methanol; S.E: Standard Error

Table 6: Percentage Inhibitory Rate (%IR) of *Sitophilus zeamais* treated with cypermethrin

Concentration (%)	Host food		
	Maize	Wheat	Sorghum
0.00001	23.53±0.13 ^b	44.80±0.31 ^b	77.75±0.16 ^b
0.0001	37.82±0.24 ^c	63.20±0.50 ^c	80.20±0.73 ^b
0.001	57.98±0.46 ^d	70.40±0.33 ^{cd}	83.37±0.14 ^b
0.01	73.11±0.83 ^c	72.00±0.63 ^{cd}	85.09±0.23 ^b
0.1	79.83±0.32 ^c	80.00±0.36 ^d	90.71±0.06 ^b
Control A	6.72±0.31 ^a	14.40±0.14 ^a	4.65±0.12 ^a
Control B	0.00±0.00 ^a	0.00±0.00 ^a	0.00±0.00 ^a

Mean values followed by the same letter(s) are not significantly different ($P>0.05$) by Tukey's Test. Control A: Solvent control, Control B: Ordinary control. Control A: control with only methanol; Control B: control with neither cypermethrin nor methanol; S.E: Standard Error

Table 7: Effect of *Sitophilus zeamais* on weight loss in grains treated with cypermethrin.

Concentration (%)	Host food		
	Maize	Wheat	Sorghum
0.00001	5.99±0.26 ^b	7.55±1.98 ^{cd}	9.45±0.31 ^{cd}
0.0001	5.94±0.13 ^b	7.43±0.74 ^{cd}	5.56±0.27 ^{bc}
0.001	3.93±0.11 ^{ab}	5.80±1.63 ^{bc}	5.15±0.31 ^{bc}
0.01	1.43±0.36 ^a	2.08±1.20 ^{ab}	2.29±1.44 ^{ab}
0.1	0.33±0.13 ^a	0.39±0.08 ^a	0.48±0.23 ^a
Control A	11.71±0.96 ^c	10.11±1.57 ^{de}	9.90±0.20 ^c
Control B	12.07±0.17 ^c	13.18±1.06 ^e	12.05±1.09 ^c

Mean values followed by the same letter(s) are not significantly different ($P>0.05$) by Tukey's Test. Control A: Solvent control, Control B: Ordinary control. Control A: control with only methanol; Control B: control with neither cypermethrin nor methanol; S.E: Standard Error.

wheat (17.25) at the lowest experimental concentration (0.00001%).

Irrespective of the host food type, there was no complete inhibition (100%) in adult emergence of *S. zeamais* (Table 6). The rate of inhibition (%IR) in emergence however increased with increasing concentration of cypermethrin irrespective of the food type. Also, cypermethrin was able to significantly inhibit ($p < 0.05$) emergence of *S. zeamais* in treated maize, wheat and sorghum grains when compared to both controls. The highest inhibition (90.71%) was observed in sorghum grains treated with the highest experimental concentration (0.1%) when compared to inhibition rate in treated maize (79.83%) and wheat (80.00%) grains. No significant difference ($p < 0.05$) was observed in the inhibition rate of weevils that emerged on sorghum treated with cypermethrin.

Weight loss in infested maize, wheat and sorghum grains treated with cypermethrin

Weight loss reduced with increasing concentration of cypermethrin regardless of the food host (Table 7). The insecticide nevertheless evoked a significant reduction in weight of maize ($F_{6,21} = 10.65$; $p < 0.0001$), wheat ($F_{6,21} = 11.06$; $p < 0.0001$) and sorghum grains ($F_{6,21} = 3.45$; $p = 0.016$). Also, weight loss at 0.01 and 0.1% was significantly lower than those of the controls. Lowest range of weight loss was however observed in treated maize grains (0.33-5.99g) while highest range of weight loss was observed in treated sorghum grains (0.48-9.45g).

DISCUSSION

The impact of host food type on the response of *Sitophilus zeamais* to cypermethrin was investigated in this study. Insecticidal response of *S. zeamais* to cypermethrin varied with type of food on which it was reared. Variation in the insecticidal response of weevils to this pyrethroid

could be attributed to variation in the phytochemical and nutritive constituents of wheat, maize and sorghum.

Cereals are known to contain a wide range of defensive phytochemicals, which vary considerably among species (Harborne, 1988). There might be some chemical components within maize which might have interacted adversely with the tolerance ability of the weevils or induced higher tolerance to cypermethrin as observed in the wheat and sorghum weevil populations (Benezet *et al.*, 1986; Busvine, 1971; Champ and Dyte, 1976; Liang *et al.*, 2007; Gbaye and Holloway, 2011). This could have influenced the physiology of the developing weevils from each cereal host. Similar observation has been reported in the insecticidal response of *Bemisia tabaci* fed with different plants (Liang *et al.*, 2007). Likewise, it has been established that grain on which an insect emerged influences its physiology by inducing different arrays of enzymes to varying extents (Holloway and Mackness, 1988; Gbaye *et al.*, 2012). This variation in enzyme induction is energetically expensive, depending on the chemical constituent of the host food, and thus influence several life history characters such as adult survival to chemical stressors like cypermethrin (Holloway *et al.*, 1990; Povey and Holloway, 1992).

Maize reared weevils exhibited the least insecticidal tolerance while their counterpart reared on wheat displayed highest insecticidal tolerance as revealed by LC_{75} and LC_{95} values. This may be due to higher nutritional content in wheat and sorghum grains when compared to that of maize grains. Wheat is able to provide immense energy source, in all parts of the grain kernel, including the bran, germ, and endosperm (Preedy *et al.*, 2011). This might have enhanced the wheat reared weevils' ability to withstand cypermethrin. Similarly, sorghum reared weevils also showed lower tolerance to cypermethrin when compared to their counterpart reared on wheat. Of all the three grains,

sorghum has the least size. Grain size is indispensable in insect's ability to compete for food and space during larval development. It could therefore be inferred that the smaller space in sorghum microenvironment might have led to the availability of lower nutrients for the larval stage of sorghum reared weevils, making them to have lower energy reserve to fight the toxin in cypermethrin during the adult stage. This could be responsible for their lower tolerance when compared to wheat reared weevils.

It was also observed that highest number of adult weevils emerged from treated sorghum grains when compared to their counterpart from treated maize and wheat grains despite subjecting them to the same concentration of cypermethrin. This could imply that many *S. zeamais* were able to break down the toxins within sorghum readily. The emergence of fewer adult weevils in some of the treated grains suggested that some of the adult weevils were still able to oviposit before they give in to insecticidal effect of cypermethrin. Although cypermethrin is known to be active against immature stages of stored product insects within grains (Semple *et al.*, 1992); the emergence of adults from maize, wheat and sorghum also shows that the immature stages of *S. zeamais* were able to survive the concentrations of cypermethrin used in this study.

This study also showed that cypermethrin was able to inhibit the rate at which adult weevils emerged. This is in agreement with the work of Morallo and Obra (1993), where both cypermethrin and deltamethrin were found to inhibit the development of *C. chinensis* and *S. zeamais* reared on beans and maize, respectively. The higher number of adults observed in treated sorghum grains indicated that more larvae might have survived from treated sorghum grain than treated maize and wheat grains. Larval stage of *S. zeamais* within the grain is the most destructive stage due to their voracious feeding activity. Similarly, the adult stage also feed on the grain.

The destructive activity of both stages might have resulted in higher loss in weight observed in treated sorghum grain when compared to their wheat and maize counterpart. Also, the inability of cypermethrin to completely prevent loss in weight might be attributed to inability of concentrations of cypermethrin used in this study to completely prevent adult emergence of *S. zeamais*. Similar observation has been reported by Pensook *et al* (1992) on maize grain treated with pirimiphos methyl, bifenthrin and deltamethrin.

In conclusion, the use of synthetic pyrethroids like cypermethrin is very important for managing losses to insects, especially in large scale agricultural practice in many rural areas of West African countries, including Nigeria (Ofuya and Lale, 2001). Mismanagement of any form of insecticide can however lead to resistance and loss of efficacy. It is therefore desirable to advice on the use of cypermethrin to maximize effective pest management. An extensive knowledge on the various factors that could influence the efficacy of management of *S. zeamais* using cypermethrin on different cereal host is therefore indispensable for proper management. Therefore, grain handlers, peasant farmers and pest control managers should be mindful of host food on which *S. zeamais* is found when controlling them using cypermethrin insecticide. This will help to reduce the problem of pest resistance that is currently associated with synthetic insecticides.

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