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DEVELOPMENT OF *SITOTROGA CEREALELLA* (OLIVIER) ON CERTAIN CEREAL GRAINS IN BOTSWANA

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ABSTRACT: The development of *Sitotroga cerealella* (Olivier) was studied on maize (kalahari early pearl and yellow maize varieties), sorghum (segaolane and sephala varieties) and millet (serere 6A and legakwe varieties), under ambient laboratory conditions (temperature range: 25-30^{0}C and 64 -70 % R.H.). This study was done on whole, broken/cut and ground grains. The mean developmental period of *S. cerealella* on the food commodities ranged from 26.67± 0.70 days to 50.40±1.09 days in legakwe whole and ground millet, respectively. The sex ratio (male: female) of *S. cerealella* ranged from 1:1 (millet: serere 6A), 1:1.06 (sorghum: sephala), 1.12:1 (sorghum: segaolane), 1.39:1 (millet: legakwe) and 1.82:1 (maize varieties: KEP). Egg hatchability was observed to be 81.7 %. The mean adult longevity of males ranged from 5.62± 0.26 days on broken legakwe millet to 9.42±0.48 in segaolane sorghum, while longevity of females ranged from 6.31± 0.54 in serere 6A to 9.73 ± 0.75 in legakwe millet. The average percentage damage for two months storage period caused by *S. cerealella* on kalahari early pearl maize was 4.99% and 5.38% on segaolane sorghum.

Key words: *Sitotroga cerealella*, maize, sorghum, millet, developmental period

INTRODUCTION

Sitotroga cerealella (Olivier), also known as the Angoumois grain moth is a cosmopolitan moth. It is found in almost every continent where cereal grains are a main source of energy (PRAKASH and RAO, 1986; YOUSAF *et al.*, 2012) and has been recorded on cereals in many countries (HANSEN *et al.*, 2004; SHAFIQUE *et al.*, 2006; BUTRON *et al.*, 2008; UKEH *et al.*, 2008, HAMED and NADEM, 2012). This pest normally infest wheat (SHAFIQUE, 2006), rice (JULIANO, 1981), maize (ARBOGAST and THRONE, 1997) and oats (YOUSAF *et al.*, 2012). In developing countries cereals such as wheat (*Tritium* spp.), maize (*Zea mays*), rice (*Oryza sativa*) and sorghum (*Sorghum* spp.) represent the principal source of daily energy intake (ALLOTEY, 1991). There are several factors that influence preference of cereals and other stored food products by insect pests. These include the size and texture of the grain, the type of seed coat, the ability to offer proper surface for oviposition and the moisture content (HAMED and NADEEM, 2012).

In order to come up with an effective pest management strategy, it is essential to have adequate information about the development of the pest, the stage of the life cycle that causes much damage, the kind of damage it causes and the storage ecosystem (ALLOTEY, 1991). Despite the importance of *S. cerealella*, and prior to the present study, no research been done on the development of *S. cerealella* on food commodities that are consumed in Botswana and under prevailing environmental conditions in Botswana. It is essential to study the development of this pest in agricultural produce that are utilized locally. Studies conducted by CONSOLI and AMARAL (1995), and SHAFIQUE *et al.*, (2006) showed that the *S. cerealella* developmental period on stored products varied depending on the variety or the genotype of the cereal. The objective of the present study is to obtain information on the development and damage caused by *S. cerealella* when reared on maize (*Zea mays*), millet (*Pennisetum* sp.) and sorghum (*Sorghum vulgare*) varieties under ambient laboratory conditions in Botswana. The study comprised egg hatchability, developmental period, adult longevity and sex ratio of emerged adults.

MATERIALS AND METHODS

Cultures of *S. cerealella* were established in glass jars (85 mm diameter × 165 mm deep) using whole grain maize at the insectary of the Department of Biological Sciences, University of Botswana. *S. cerealella* moths were obtained from the laboratory stock cultures reared in large glass jars on whole grain maize. All cultures and experimental jars were maintained at room temperature range 25 - 30°C with alternating 12-h light and 12-h dark cycles, and 64-70% R.H. All equipment used in handling the insects were sterilised at 90°C. The food commodities were heat treated at 80°C in a dry oven for three hours as a routine measure to prevent diseases or cross infestations (ALLOTEY and RAMONGALO, 2011).

Ten newly emerged adults were placed into a jar containing 8 cm x 30 cm black paper that is folded 11 times and stapled in the centre in order to provide an oviposition site. The set up was left undisturbed for about 12-24 hours to allow mating and egg laying by moths. When sufficient numbers of eggs were laid the folded paper was removed, unstapled and then unfolded. The eggs were removed with a fine brush and placed into a petri-dish. Twenty uncollapsed eggs of about 24 hours were collected with a fine brush and placed into a petri-dish. Fine food particles of maize meal were placed around the egg mass. This was to ensure that newly emerged larvae started feeding immediately after hatching in order to prevent egg cannibalism (ALLOTEY and GOSWAMI, 1990). Egg hatching was observed daily and the number of newly hatched larvae was noted.

The developmental period of *S. cerealella* was studied on maize, millet and sorghum varieties. Approximately 3g of each cereal was placed in a glass vial (25 mm diameter × 76 mm deep). Two newly hatched larvae from the method described above were introduced into each glass vial using a fine brush. The vial was covered with a muslin cloth held in place by a rubber band to allow for aeration. In all 40 replicates of each food commodity were prepared and the set-up was left uninterrupted until the moths emerged (ALLOTEY AND RAMONGALO, 2011). Emergence, developmental period, sex-ratios and adult longevity were observed and recorded daily. Approximately 200 g of kalahari early pearl maize were weighed into a 2 litre jar in four replicates. Fifty newly laid eggs of *S. cerealella* were placed into two jars except for the control. The same procedure was repeated using Segaolane sorghum variety. The experimental set-up was left undisturbed until emergence of adults. The adults were removed and the grains sieved out in order to determine the loss and damage caused. This was done by weighing the food commodity and noting the differences between the initial weight and the final weight of the particular food commodity (ALLOTEY and GOSWAMI, 1990).

RESULTS AND DISCUSSION

Eggs: Adults of *S. cerealella* lay their eggs on grains. Eggs are whitish when there are laid but become reddish after some days (REEDS, 2004). Eggs of *S. cerealella* are laid either singly or in clusters inside the folded paper used as an oviposition site. An average of 150 eggs can be laid by one female *S. cerealella* adult (REEDS (2004). Eggs are translucent when they are freshly laid but became embroynated and reddish in colour after about 3-4 days as shown by Fig. 1. In the present study, the incubation period of eggs was 4-7 days at a temperature range 25-30°C and 64-70% R.H. HANSEN *et al.* (2004) recorded egg incubation period of 4.99 days to 6.56 days at temperatures between 25 and 30°C. The number of eggs laid is determined by the season, the temperature and the food variety. In lower temperatures and relative humidity, egg hatchability is reduced. The egg hatchability is usually between 70-100% depending on the genotype of the food commodity and other environmental factors such as temperature and relative humidity (CONSOLI and AMARAL, 1995). The egg hatchability of *S. cerealella* on Kalahari early pearl (white maize) was 81.70% and was higher compared to the 76.33% hatchability recorded by AHMED and RAZA (2010) on a white maize variety.

Mean developmental period: Mature larva of *S. cerealella* is yellowish with a darker head which is bigger than the posterior part of the larva. The length of the larva is about 5 mm and the size of the larva is influenced by the sex, the type of cereal, temperature and relative humidity. The larvae are not usually seen as they live inside the grains and they are the destructive stage (REEDS, 2004). The developmental period can be significantly different in different varieties of a particular cereal. In Table 2 small letters a to g indicate whether there was a significant difference between mean developmental period of *S. cerealella* in whole, broken and ground grains of millet, sorghum and maize. If the letters are the same it indicates that there is no significant difference between the mean developmental periods of different food media. The mean developmental period of *S. cerealella* in different food commodities (sorghum, millet and maize) varied from 26.67± 0.70 days to 50.40±1.09 days on Legakwe whole and ground (millet), respectively. From table 2, the mean developmental period in days of *S. cerealella* on different food media can be summarized as follows:

On whole grains:
Legakwe ($\bar{x}$=26.67) < Segaolane ($\bar{x}$=31.58) < Serere 6A ($\bar{x}$=31.67) < Sephala ($\bar{x}$=38.24) < Yellow maize ($\bar{x}$=43.67) < Kalahari Early Pearl maize ($\bar{x}$=50.04)

Thus shortest developmental period of *S. cerealella* on whole cereal grains was found on Legakwe millet, while the longest developmental period was on Kalahari Early Pearl maize. Least percentage emergency of *S. cerealella* adults of 12.5% on whole grains was recorded in yellow maize (Table 2). This may be due to hard testa of yellow maize as compared to white maize. The highest percentage emergence of 80% was recorded in Segaolane broken. Table 2 shows that generally high emergence was recorded in broken grains than in whole grains of each food variety. This may be due to easy exit between broken grains and the more early exposure of the endosperm to *S. cerealella* larvae leading to increased emergence of adults (AYERTEY, 1982).

Mean developmental period on cut and broken grains: Legakwe ($\bar{x}$ = 31.57) < Sephala ($\bar{x}$ = 39.91) < Segaolane ($\bar{x}$ = 42.80) < Kalahari Early Pearl maize ($\bar{x}$ = 43.08) < Serere 6A ($\bar{x}$ = 43.25) < Yellow maize ($\bar{x}$ = 43.6).

Thus *S. cerealella* took least number of days to complete development on Legakwe millet and longest period of time on yellow maize. In general mean developmental period for each cereal variety was extended in broken/cut grains as compared to whole grains (Table 2). This may be due to insufficient wall in broken grains for the adults to develop since *S. cerealella* normally develop inside a complete wall of a grain (AYERTEY, 1982).

Mean developmental period on ground grains: Yellow maize ($\bar{x}$ = 34.75) < Kalahari Early Pearl maize ($\bar{x}$ = 36.8) < Segaolane ($\bar{x}$ = 41.80) < Sephala ($\bar{x}$ = 42.36) < Serere 6A ($\bar{x}$ = 43.25) < Legakwe ($\bar{x}$ = 50.40).

The longest mean developmental period of 50.40 days was recorded in Legakwe ground. One reason for the prolonged mean developmental period could be due lack of complete physical wall of endosperm formed by the developing larvae. Normally the larvae are internal feeders surrounded by a "complete wall" of endosperm (AYERTEY, 1982). Development of *S. cerealella* is influenced by different environmental conditions such as temperature and relative humidity. Optimum temperature for development of *S. cerealella* is 25-30 C° and the optimum relative humidity is 60-75 %. At 30°C the developmental period is about 30 days while at 25°C it is about 40 days (PEREZ-MENDOZA *et al.*, 2004).

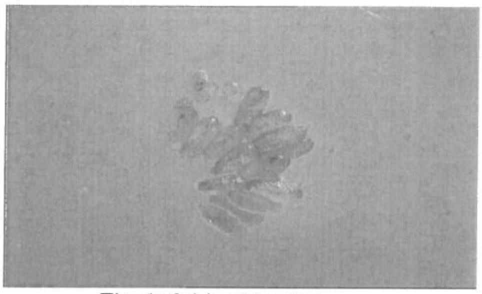

Fig-1: 24 h old eggs

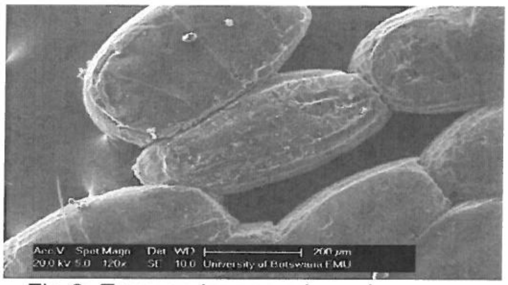

Fig-2: Eggs under scanning microscope

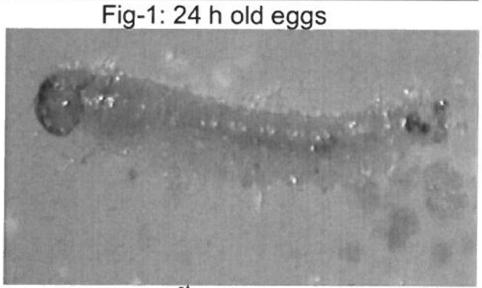

Fig-3: 1st instar larva

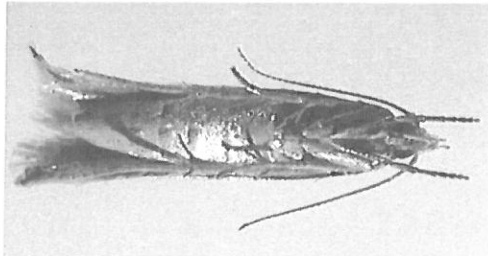

Fig-4: Ventral view of adult

Longevity: The mean longevity of *S. cerealella* on different food commodities ranged from 4.40±0.51 on Sephala sorghum to 9.73±0.75days on Legakwe millet. In a study carried out by HANSEN *et al.* (2004) mean longevity of *S. cerealella* ranged from 5.80± 0.19 to 7.10 ± 0.24 on maize strain. In the present study longevity of females ranged from 4.40±0.42 days on Sephala sorghum to 9.73±0.75 on Legakwe millet. Mean adult longevity in males ranged from 4.40±0.51 in Sephala to 9.42±0.48 in Segaolane (Table-6).

Sex ratio: The sex ratio (male: female) of *S. cerealella* on whole grains ranged from 1:1 (Millet- Serere 6A), 1:1.06 (Sorghum-Sephala), 1.12:1 (Sorghum-Segaolane), 1.39:1 (millet-Legakwe) and 1.82:1 (maize varieties-KEP) (Table 7). HANSEN *et al.*, (2004) recorded a sex ratio of 1.08:1 (males: females).

Damage and loss assessment: The damage imposed on the grains of cereals was measured as quantity loss (weight loss) due to the feeding activities of the larvae of *S. cerealella.* 4.99±0.08 and 5.38±0.20 percentage weight loss due to infestation by *S. cerealella* was recorded in Kalahari Early pearl maize and Segaolane sorghum, respectively (Table 8).

In general, damage caused to cereal grains by *S. cerealella* is enormous and can lead to huge economic losses. The larvae of *S. cerealella* feed on grains and cause both direct and indirect damage to the grains. The infested grains become less attractive for consumption, have an unpleasant smell, and show decrease in weight, quality and nutritional value (HASHEM *et al.*, 2012). The larvae release their excretory products on the grains, feed and breed on the grains which speed up the deterioration process of the grain (ALLOTEY, 1991). *S. cerealella* contaminates more grains than it bore/eat, the contamination may be due to presence of pupal cases and fecal pellets inside grains and presence of dead and live insects in grains.

Table- 1: Hatchability of eggs of *S. cerealella* reared on maize.

Mean (x± S.E.)	n_h	N	% Hatchability
29.03± 2.18 (4-127.0)*	3043	3724	81.70%

n_h = number of hatched eggs; N = Total number of eggs utilized; * = Range in parentheses

Table- 2: mean developmental periods of *S. cerealella* reared on different food commodities **(N=80)** [a]

Food media	Mean dev. Period ± S.E. (days)	n	% Emergence
Sorghum			
Sephala (whole)	38.24± 1.42 [c*] (27-56)#	37	46.3
Sephala(broken)	39.91 ± 1.07 [c] (32-54)	55	68.8
Sephala(ground)	42.36 ±0.49 [d] (40-45)	11	13.8
Segaolane (whole)	31.58± 1.20[b] (28-35)	53	66.3
Segaolane (broken)	42.80± 0.78 [d] (26-59)	64	80
Segaolane (ground)	41.8±0.59[d] (39-45)	10	12.5
Millet			
Serere 6A (whole)	31.67± 0.84 [b] (25-43)	24	30
Serere 6A (Broken)	42.84± 0.67 [d] (30-53)	49	61.3
Serere 6A (Ground)	43.25±0.45[g] (42-45)	8	10
Legakwe (whole)	26.67± 0.70[a] (16-48)	55	68.8
Legakwe (broken)	31.57± 0.46 [b] (27-40)	58	72.5
Legakwe (ground)	50.40±1.09 [e] (31-64)	10	12.5
Maize			
KEP maize (whole)	50.04± 0.95[e] (35-59)	48	60
KEP maize (cut)	43.08±0.40[g] (40-47)	25	31.3
KEP maize (ground)	36.8±0.74[f] (34-42)	10	12.5
Yellow maize (whole)	43.67±1.08[g] (45-55)	10	12.5
Yellow maize (cut)	34.75±1.20[f] (42-46)	3	3.75
Yellow maize (ground)	34.75±0.4[f] 8(34-36)	4	5.00

* Means in the same vertical columns followed by the same letter do not differ significantly at the 5 % level by the Duncan multiple range test; [a] N= actual number of first instar larvae introduced, n= Number of emerged adults observed; **#** = Range in parentheses

Table- 3: Kruskal-Wallis ANOVA on ranks for mean developmental period of *S. cerealella* reared on different whole food media.

Group	N	Median	25%	75%
Sephala	37	36.00	30.50	46.25
Segaolane	64	32.00	30.00	33.00
Serere 6A	24	31.00	29.00	34.00
Legakwe	55	26.00	24.00	28.00
KEP maize	48	52.00	47.50	54.00
Yellow maize	10	49.50	48.00	53.00

Table- 4: Kruskal-Wallis ANOVA on ranks for mean developmental period of *S. cerealella* reared on different broken food media.

Group	N	Median	25%	75%
Sephala	55	39.00	32.25	44.75
Segaolane	53	42.00	40.00	44.00
Serere 6A	49	44.00	42.75	45.00
Legakwe	58	31.00	29.00	34.00
KEP maize	25	43.00	41.00	44.00
Yellow maize	3	43.00	42.25	45.25

Table- 5: Kruskal-Wallis ANOVA on ranks for mean developmental period of *S. cerealella* reared on different ground food media

Group	N	Median	25%	75%
Sephala	11	42.00	41.25	43.75
Segaolane	10	42.00	40.00	43.00
Serere 6A	8	43.00	42.00	44.50
Legakwe	10	56.00	55.00	62.00
KEP maize	10	37.00	35.00	38.00
Yellow maize	4	34.50	34.00	35.50

Table- 6: Adult longevity of emerged *S. cerealella* on reared on different food commodities.

Food media	**Mean adult longevity (days)**	
Sorghum verities	Males	Females
Sorghum		
Sephala (whole)	6.59±0.92	8.60±0.59
Sephala(broken)	5.94±0.42	8.67±0.66
Sephala(ground)	4.40±0.51	4.40±0.42
Segaolane (whole)	9.42±0.48	9.50±0.45
Segaolane (broken)	8.63±0.62	8.37±0.59
Segaolane (ground)	5.40±0.51	7.00±0.62
Millet		
Serere 6A (whole)	5.88±0.61	6.31±0.54
Serere 6A (Broken)	6.50±0.36	7.1±0.50
Serere 6A (Ground)	5.25±0.25	5.00±0.41
Legakwe (whole)	8.81±0.53	8.52±0.61
Legakwe (broken)	5.62±0.26	9.73±0.75
Legakwe(ground)	7.25±0.48	7.00±01.48
Maize		
KEP maize (whole)	6.89±0.28	8.22±0.59
KEP maize (cut)	6.25±1.03	6.20±0.74
KEP maize (ground)	6.25±1.03	5.01±0.57
Yellow maize (whole)	6.33±0.58	5.20±0.48
Yellow maize (cut)	6.00±0.00	4.51.00±0.50
Yellow maize ground	6.00±0.00	5.00±0.00

Table- 7: Summary of sex-ratios of emerged *S. cerealella* on different food commodities.

Food media	Males	Females	Emergence	Sex-ratio
Sorghum				
Sephala (whole)	18(48.6%)	19(51.4%)	37	1:1.06
Sephala(broken)	35(63.6%)	20(36.4%)	55	1.75:1
Sephala(ground)	6(54.5%)	5(45.5%)	11	1.2:1
Segaolane (whole)	28(52.8%)	25(47.2%)	53	1.12:1
Segaolane (broken)	39(60.9%)	25(39.1%)	64	1.56:1
Segaolane (ground)	5(50%)	5(50%)	10	1:1
Millet				
Serere 6A (whole)	12(50%)	12(50%)	24	1:1
Serere 6A (Broken)	29(59.2%)	20(40.8%)	49	1.45:1
Serere 6A (Ground)	4(50%)	4(50%)	8	1:1
Legakwe (whole)	32(58.2%)	23(41.8%)	55	1.39:1
Legakwe (broken)	35(60.3%)	23(39.7%)	58	1.52:1
Legakwe(ground)	5(50%)	5(50%)	10	1:1
Maize				
KEP maize (whole)	31(64.6%)	17(35.4%)	48	1.82:1
KEP maize (cut)	12(48%)	13(52%)	25	1:1.08
KEP maize (ground)	5(50%)	5(50%)	10	1:1
Yellow maize (whole)	5(50%)	5(50%)	10	1:1
Yellow maize (cut)	2(66.7%)	1(33.3%)	3	2:1
Yellow maize ground	2(50%)	2(50%)	4	1:1

Table- 8: Damage caused by *S. cerealella* to maize and sorghum stored for 2 months in 2 litre jars (N=4).

Commodity	Initial weight (g)	Final weight (g)	Weight loss (g)	Percentage weight loss (%)	Emerged adults
Kalahari early pearl maize	200	190.03	9.98±0.17	4.99±0.08	43
segaolane sorghum	200	189.30	10.75±0.40	5.38±0.20	36.75

N= four replicates of 50 eggs per replicate.

CONCLUSION: In the tropics having warmer climate, storage pests are a major problem as most insects develop quickly in warmer conditions (ALLOTEY, 1988, 1991; ALLOTEY and RAMONGALO, 2011). Unfortunately due to limited knowledge on pest management systems, farmers lose most of their harvest to attack by insects pests such as the *S. cerealella*. The amount of losses of cereals during storage due to insect pests differ from one country to another. Modifying the environmental conditions can be used as a pest control measure but it requires adequate knowledge about the biology of the insect pest and the physical characteristics of the grains. Chemicals having a correct blend of biological activity can be used to treat grains and grain stores to limit the population of insect pests. Contact insecticides can also be used (ALLOTEY, 1991). However, *S. cerealella* is even more difficult to control using chemicals as compared other insect pests, because of its high ability to develop resistance to insecticides and being an internal feeder, which help the larvae to avoid direct contact with insecticides (BOSHRA, 2007). Thus knowledge of the developmental period, sex ratios, damage caused by *S. cerealella* to important cereals utilized in Botswana will be useful in planning strategic pest management program against this pest.

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REFERENCES

AHMED, S. and RAZA, A. 2010. Antibiosis of physical characteristics of maize grains to *Sitotroga cerealella* (Oliv.) (Gelechiidae: Lepidoptera) in free choice Test. *Pakistan J. Life Social science* **8** (2): 142-147.

ALLOTEY, J. 1988. A study of the insects pests on stored palm produce in Port Harcourt, Nigeria. *J. Stored Prod. Res.* **24** (3): 237-240.

ALLOTEY, J. (1991). Storage insect pests of cereal in small scale farming community and their control. *Insect Sci. and Its Applic.* **12** (5/6): 679-693.

ALLOTEY, J. and GOSWAMI, L. 1990. Comparative biology of two phycitid moths, *Plodia interpunctella* (Hubn.) and *Ephestia cautella* (Wlk.) on some selected food media. *Insect Sci. and Its Applic.* **11** (2): 209-215.

ALLOTEY, J. and RAMONGALO, B. 2011. Development of *Ephestia cautella* (Wlk.) on some food commodities in Botswana. *J. Appl. Zool. Res.* **22**(2): 119-130.

ARBOGAST, R.T. and THRONE, J.E. 1997. Insect Infestation of farm-stored maize in South Carolina: Towards characterization of a habitat. *Transportation Research: Part D: Transport and Environment* **2** (3): 187-198.

AYERTEY, J. N. 1982. Development of *Sitotroga cerealella* on whole cracked or ground maize. *Entomological Experiments and Applications* **31**: 165-169.

BOSHRA, S.A. 2007. Effect of high-temperature pre-irradiation on reproduction and mating competitiveness of male *Sitotroga cerealella* (Olivier) and their F1 progeny. *J. Stored Prod. Res.* **43** (1): 73-78.

BUTRON, A., ROMAY, M., ORDAS, A., MALVAR, R., and REVILLA, P. 2008. Genetic and environmental factors reducing the incidence of the storage pest *Sitotroga cerealella* in maize. *Entomologia Experimentalis et Applicata* **128** (3): 421-428.

CONSOLI, F. and AMARAL, B. 1995. Biology of *Sitotroga cerealella* (Oliv.) (Lepidoptera, Gelechiidae) reared on 5 corn (maize) genotypes. *J. Stored Prod. Res.* **31** (2):139-143.

HAMED, M and NADEEM, S. 2012. Effect of cereals on the development of *Sitotroga cerealella* (Olivier) (Lepidoptera: Gelechiidae) and subsequent quality of the egg parasitoid, *Trichogramma chilonis* (Ishii) (Hymenoptera: Trichogrammatidae). *Pakistan Journal of Zoology* **44** (4): 923-929.

HANSEN, L.S., SKOVGARD, H and HELL, K. 2004. Life table study of *Sitotroga cerealella* (Lepidoptera: Gelechiidae) a strain from West Africa. *J. Econ. Entomol.* **97** (4): 1484-1490.

HASHEM, M.Y., RISHA, E.S.M., EL-SHERIF, S.I and AHMED, S.S. 2012. The effect of modified atmospheres, an alternative to methyl bromide, on the susceptibility of immature stages of Angoumois grain moth *Sitotroga cerealella* (Olivier). *J. Stored Prod. Res.* **50**: 57-61.

JULIANO, B.O. 1981. Rice grain properties and resistance to storage insects: A review. *IRRI Research Paper series* **56**:1-9.

PEREZ-MENDOZA, J., WEAVER, D., and THRONE, J. 2004. Development and survivorship of immature Angoumois grain moth (Lepidoptera: Gelechiidae) on stored corn. *Environ. Entomol.* **33** (4): 807-814.

PRAKASH, A. and RAO, J. 1986. Angoumois grain moth: a serious most pest of stored paddy, Bull. Grain Technol. **24** (3): 240-247.

REEDS, D. 2004. Insects of stored products. *CSIRO pub.* p126.

SHAFIQUE, M., AHMAD, M. and CHAUDRY, M.A. 2006. Evaluation of wheat varieties for resistance to Angoumois Grain Moth, *Sitotroga cerealella* (Olivier), (Lepidoptera: Gelechiidae). *Pakistan Journal of Zoology* **38** (1): 7-10.

UKEH, D.A., IDORENYIN, A.U. and OGBAN, I.O. 2008. Trapping of stored-product insects using flight traps outside traditional African storage granaries. *J. Fd. Agric. and Environ.* **6** (2): 399-401.

YOUSAF, S., MOHSIN, A., ASLAM, M., AHMAD, M. and GHAFFAR, A. (2012). Impact of *Sitotroga cerealella* on the viability of oat seed. *Pakistan Entomol.* **34** (2): 75-78.