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Effect of Feeding of Different Rice Varieties on Biology of Angoumois Grain Moth (*Sitotroga cerealella* Olivier.) in *Terai* Region of West Bengal, India

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Abstract

Studies on feeding effect of different rice varieties on biology of Angoumois grain moth (*Sitotroga cerealella* Olivier.) in *terai* region of West Bengal conducted during 2007-2009 at the Laboratory, Department of Agricultural Entomology, Uttar Banga Krishi Viswavidyalaya, Pundibari, Cooch Behar, revealed that the favorable season for the development of *S. cerealella* is the post-monsoon months when it takes only 34.59 days to complete one generation and the optimum climatic conditions is 26.68-29.23^{0}C and 66.16% RH. followed by 41.00-55.00 days with an average of 44.12 days at 23.95^{O}C and 72.75% RH. during autumn months, in 89.16-103.25 days with an average of 98.86 days at 20.62^{O}C and 71.45% RH. during winter months. The insect failed to develop completely in most of the varieties during winter. Among the twenty four different genotypes the insect took minimum time to complete its development when the rearing grain was PNR-519 during post-monsoon, Tulsimanjuri, Tulsibhog and Kanak during autumn and in UBSR-2 during winter.The duration was found to be longer in Swarna Mashuri during winter, IR-68 and Kanak during post-monsoon and during autumn in Nauda and IR-68. With respect to fecundity Mashuri, Swarna Mashuri and China Boro, were found to be suitable for the infestation of *Sitotroga cereallela* during post monsoon, Swarna Mashuri, Nauda and Ajaya during autumn and Swarna Mashuri and IET 4786 during winter months in *terai* region of West Bengal.

1. Introduction

The Angoumois grain moth (*Sitotroga cerealella* Oliver.) is worldwide in distribution. It attacks the grains of all cereals and millets both in field as well as in storage condition (Champ and Dyte, 1977; Anand Prakash et al., 2004). It is a major pest of stored rice, maize, wheat, sorghum and oat (Shahjahan, 1974; Champ and Dyte, 1977; Shazali and Smith, 1985; Pathak and Jha, 2003). The damage caused by the insect ranged from 0.43 to 6.18 % in rice (Khanam et al., 1993, Uttam et al., 2002; Rai, 2003), 5 to 16.6% in wheat (Chatterjii, 1953), 47.9% in stored maize (Pathak and Jha, 2003). Biological activities of the species, varied with climatic conditions as well as food grain, are influenced by grain characters of the variety which indicates its susceptibility to different grain varieties. Despite the importance of this pest, quantitative data describing its life history over a range of environmental conditions at which it will develop are lacking. Initiative had already been taken by number of scientists (Chatterjii, 1953; Pandey and Pandey, 1976; Uttam et al., 2002; Anand Prakash et al., 2004) to study the biological activities and the impact of different physical characters of grain for future resistant breeding program in India but they did not cover the terai region of West Bengal. This consideration leads to study the biology of S. cerealella feeding on different rice varieties grown in terai region of West Bengal, India for formulation of management program.

2. Materials and Methods

Studies on biology of *S. cerealella* were conducted during 2007-2009 in three seasons namely post-monsoon (September-October), autumn (October-November) and winter (December-March) in the laboratory of the Department of Agricultural Entomology, Uttar Banga Krishi Viswavidyalaya (UBKV), Pundibari, West Bengal, India. The grains of 24 paddy varieties commonly grown in the terai region of West Bengal like Sita, IR-50, Swarna Mashuri, Nauda, IET-10391, IR-68, Sadabhog, MW-10, Ajaya, Kanak, Tulsibhog, Tulsimanjuri, Mashuri, UBSR-2, Pusa Basmati, IET-4786, Biplab, IET-9947, PNR-519, China Boro, IET-13544, IET-4315, Dhansagar,

UBSR-3, were collected from the University Farm and Department of Genetics and Plant Breeding, UBKV, Pundibari, Cooch Behar, West Bengal, India. The grains of the test varieties were thoroughly cleaned in clean water to remove dirt and inert matter. They were disinfected in hot air oven and stored in plastic jars under laboratory conditions. The parent culture of S. cerealla was maintained in the laboratory of the Department of Agricultural Entomology, UBKV, Pundibari, Cooch Behar. Two pairs of freshly emerged adults were released in each jar and, were removed after completion of oviposition, i.e. after death of the moths. The total number of eggs laid by moths was counted to record their fecundity. The number of newly hatched larvae from each genotype was counted daily. The incubation period was recorded from each genotype. The number of days taken from larva to adult emergence was counted as larval-pupal period (Howe, 1971). The duration from emergence to egg laying and finally to death was counted as adult longevity. The total duration from egg to adult emergence were recorded to count the duration of life cycle from each 24 genotypes of paddy. The data were analysed statistically by using EXCEL, SPSS and INDOSTAT.

3. Results and Discussion

Under present investigation five important biological parameters namely fecundity, incubation period, larval-pupal period, adult longevity and life cycle were taken into consideration to study the biology of S. cerealella on different rice varieties and the data was presented in Table 1 and 2.

3.1. Fecundity

Fecundity of S. cerealella on grains of different rice varieties over different seasons varied significantly (Table 1). Fecundity was observed significantly more during autumn months (55.62) at 25.42^{0}C and 73.83% RH followed by post-monsoon (47.50) at 29.96^{0}C and 60.27% RH. Hansen et al. (2004) recorded highest fecundity of 124 eggs female^{-1} at 20^{0}C and 80% RH on Zea mays and Al-khawass (2010) recorded fecundity of 286 on wheat. During winter month's fecundity of the pest on the grains of different paddy varieties was least 19.79 at 22.73^{0}C and 64.89% RH. EL-Nahal (1978) also observed that the fecundity increased with the RH up to 70%. In present investigation, the fecundity ranged from 28.00 to 77.00 with an average of 47.50 during post-monsoon at 29.96^{0}C and 70.27% RH which is in conformity with Prakash et al. (1987) where the moth laid an average 40 eggs ranging from 30 to 70 throughout its life on paddy. During winter months fecundity of the pest on the grains of different paddy varieties was least 19.79 at 22.73^{0}C and 64.89% RH. Among the different grains fecundity was found significantly higher on China Boro (82.00) followed by Masuri (77.00) and Swarna Masuri (65.00) while the lower being from IET-10391 (28.00) followed by UBSR-3 (31.00) during post-monsoon months. During autumn months fecundity was higher on Swarna Masuri (91.50) followed by Ajaya (77.00) and Nauda (75.00) whereas, the pest laid significantly lowest number of eggs (27.00) on Dhansagar. During winter highest fecundity was recorded from Swarna Mashuri (37.00) followed by IET-4786 (36.00) and Biplob (34.00) while on PNR-519 and IR-68 the fecundity was lowest (5.00 and 6.00), respectively.

3.2. Incubation period

Incubation period varied significantly with varieties over different seasons. Incubation period was observed significantly longest (10.01 days) during winter at 20.05^{0}C and 80.83% RH where as shortest (4.25 days) during post-monsoon months followed by autumn months (4.75 days). The findings of Manojlovic (1987) revealed that the period was longest at 20^{0}C and being shortest at 30^{0}C which further confirms the results of present studies.During post-monsoon months the longest incubation period was recorded 4.5 days from Swarna Masuri, IET-10391, IR-68, MW-10, Kanak, IET-9947, PNR-519, China Boro, IET-4315, Dhansagar and UBSR-3 while shortest from Pusa Basmati 03.50 days. The longest and shortest periods were 6.00 days from IR-50, IR-68, Sadabhog and Kanak and 3.50 days from Swarna Masuri respectively in autumn months. In winter months the period was ranged from 7-12 days, shortest being 7.00 days on IET-9947 and longest being 12.00 days on MW-10, Ajaya, Pusa Basmati and China Boro (Table 1).

3.3. Larval-pupal period

The S. cerealella passed its larval-pupal stage within the grain, therefore, it was difficult to take observation of the larval-pupal period separately within the grain. Hence, larval and pupal period were counted together.

The larval-pupal period was significantly varied on different varieties over different seasons (Table 1). Significantly longest (80.30 days) duration in larval-pupal period was recorded during winter month, whereas shortest period was recorded during post-monsoon months (28.92 days) followed by autumn (36.62 days) respectively. The observations made by Mondragon and Almeida (1988) stated that the period was 62.3 days at 20^{0}C and 70±2% RH. The differences in developmental period might be due to higher RH% level in present investigation. They also observed 39.8 days of developmental period at 25^{0}C and 70±2% RH which is also inconformity with present studies. During post-monsoon months the longest larval-pupal period was recorded on variety Sita (31.50 days) followed by Kanak (31.25 days) and the shortest being 25.00 days in China Boro followed by Sadabhog (26.00 days) and Tulsimanjuri (27.00 days). In autumn the larval-pupal period was recorded longest on Nauda (45.00 days) followed by Biplob (41.25 days) and shortest period being on Tulsimanjuri (30.00 days) followed by

Table1: Biology of *S. cerealella* on different paddy varieties in different seasons

Variety	Fecundity			Incubation			Larval-pupal period		
	Post-monsoon	Autumn	Winter	Post-monsoon	Autumn	Winter	Post-monsoon	Autumn	Winter
Sita	40.00	59.50	31.00	04.00	04.16	08.00	31.50	37.75	86.25
IR-50	48.00	40.00	12.00	4.00	06.00	08.00	28.50	34.25	00.00
Swarna Mashuri	65.00	91.50	37.00	04.50	03.50	11.00	29.00	34.00	84.00
Nauda	52.00	75.00	11.00	04.00	05.00	11.50	29.00	45.00	00.00
IET-10391	28.00	42.00	23.00	04.50	03.75	11.00	29.50	40.00	00.00
IR-68	51.00	48.00	6.00	04.50	06.00	07.50	30.25	40.25	83.16
Sadabhog	53.00	51.50	31.00	04.00	06.00	09.00	26.00	34.50	77.16
MW-10	37.50	45.00	21.00	04.50	05.00	12.00	30.50	33.50	78.96
Ajaya	39.00	77.00	22.00	04.00	04.50	12.00	27.75	35.25	82.00
Kanak	44.00	42.00	10.00	04.50	06.00	13.00	31.25	31.00	00.00
Tulsibhog	45.00	68.00	30.00	04.00	05.50	10.00	30.00	31.50	00.00
Tulsimanjuri	57.00	46.00	20.00	04.25	05.00	09.50	27.00	30.00	77.16
Masuri	77.00	56.00	17.00	04.25	04.00	11.00	28.75	39.00	82.50
UBSR-2	37.00	64.00	13.00	04.25	04.50	09.50	30.75	35.75	72.50
Pusa Basmati	42.00	47.00	12.00	03.50	05.00	12.00	29.75	35.00	00.00
IET-4786	52.00	61.00	36.00	04.00	04.00	08.83	29.00	37.00	78.16
Biplab	44.00	40.00	34.00	04.25	05.00	08.00	29.75	41.25	00.00
IET-9947	45.00	70.00	10.00	04.50	05.00	07.00	27.75	37.50	00.00
PNR-519	38.50	60.00	5.00	04.50	04.00	11.00	28.75	38.25	78.50
China Boro	82.00	54.00	24.00	04.50	05.00	12.00	25.00	37.50	00.00
IET-13544	53.50	65.00	28.00	04.00	03.75	07.00	29.00	40.50	00.00
IET-4315	40.00	48.50	19.00	04.50	04.00	11.50	27.50	35.50	00.00
Dhansagar	38.50	27.00	15.00	04.50	04.00	09.50	28.50	37.50	00.00
UBSR-3	31.00	57.00	8.00	04.50	05.50	10.50	29.50	37.15	00.00
Mean	47.50	55.62	19.79	4.25	4.75	10.01	28.92	36.62	80.03
	Fecundity			Incubation			Larval-pupal period		
Interaction	V	S	V x S	V	S	V x S	V	S	V x S
SEm (±)	0.3768	0.1332	0.6526	0.3010	0.1064	0.5213	0.3211	0.1135	0.5562
CD (p=0.05)	0.7448	0.2633	1.2900	0.5949	0.2103	1.0305	0.6347	0.2244	1.0994

Kanak (31.00 days) and Tulsibhog (31.50 days). During winter months the larval-pupal period was longest on Sita (86.25 days) followed by Swarna Masuri (84.00 days) and shortest on UBSR-2 (72.50 days) followed by Sadabhog and Tulsimanjuri (77.16 days). However, the development was incomplete when reared on IR-50, Nauda, IET-10391, Kanak, Tulsibhog, Pusa Basmati, Biplob, IET-9947, China boro, IET-13544, IET-4315, Dhansagar and UBSR-3 and therefore, no moth emergence was recorded from grains of these varieties.

3.4. Adult longevity

3.4.1. Female

The longevity of female varied significantly among different varieties over seasons (Table 2). The longest period was recoded 8.40 days in winter followed by 5.13 days in autumn and 2.97 days in post-monsoon months respectively. During post-monsoon months the longest and shortest periods were found 4.15 days from Sadabhog and 2.15 days from UBSR-2, respectively. In autumn months the period was longest when reared on Sadabhog 7.25 days followed by 6.00 days from IET 4315, UBSR-2, Tulsimanjari, MW-10 and shortest being from UBSR-3, Biplob and Ajaya (4.00 days). During winter the longest period was recorded from IET-4786 (12.32 days) followed by 11.00 days from Sadabhog and 10.99 days from IET-4315, while the shortest duration was observed 6.58 days from IR-50 followed by China boro and Tulsibhog (6.66 days).

3.4.2. Male

Similarly longevity of male recorded more (7.36 days) during

winter months while being shortest (2.34 days) during post-monsoon months followed by autumn months (4.79 days) (Table 2). The longest (2.00 days) period were recorded on MW-10 and shortest being 0.90 days on IET-4786 during post-monsoon months. In autumn months longest (5.35 days) period was observed on Swarna Masuri, Nauda, Sadabhog, IET-4315 and Masuri shortest being 4.10 days on IET-13544 followed by Sita, IET-9947 and Biplob (4.35 days). During winter months the period was found longest (9.90 days) on Ajaya followed by IET-4315 (9.73 days), Sadabhog (9.25 days)

Table 2: Biology of *S. cerealella* on different paddy varieties in different seasons

Variety	Adult longevity						Life cycle duration		
	Female			Male			Post-monsoon	Autumn	Winter
	Post-monsoon	Autumn	Winter	Post-monsoon	Autumn	Winter			
Sita	02.90	04.92	08.50	2.15	4.35	7.90	38.73	47.17	102.75
IR-50	02.90	05.50	06.58	2.15	4.60	7.66	35.40	45.17	Incomplete
Swarna Mashuri	03.90	05.50	08.25	2.50	5.35	9.06	37.40	44.00	103.25
Nauda	02.90	05.00	09.66	2.20	5.35	9.06	35.90	55.00	Incomplete
IET-10391	02.65	05.00	07.00	2.40	4.85	6.90	36.65	48.00	Incomplete
IR-68	03.15	04.25	07.67	2.40	4.85	6.40	38.06	50.00	93.33
Sadabhog	04.15	07.25	11.00	2.50	5.35	9.25	34.15	47.75	97.16
MW-10	02.25	06.00	08.33	3.00	4.60	7.90	37.25	44.50	99.29
Ajaya	03.30	04.00	09.18	2.50	4.85	9.90	35.05	43.75	103.18
Kanak	03.65	04.75	07.14	2.40	4.85	6.38	39.40	41.75	Incomplete
Tulsibhog	02.90	04.75	06.66	2.40	5.10	7.06	36.90	41.75	Incomplete
Tulsimanjuri	02.90	06.00	07.99	2.15	4.60	8.23	34.15	41.00	94.65
Masuri	02.90	05.25	08.82	2.20	5.35	6.56	35.90	48.25	102.32
UBSR-2	02.15	06.00	07.16	2.15	4.85	6.56	37.15	46.25	89.16
Pusa Basmati	03.25	04.75	07.32	2.50	4.60	6.40	35.25	44.75	Incomplete
IET-4786	02.25	04.25	12.32	1.90	4.60	8.56	37.33	45.25	98.78
Biplab	03.25	04.00	10.00	2.50	4.35	7.90	34.58	50.25	Incomplete
IET-9947	02.90	04.25	08.83	2.40	4.35	6.73	35.90	40.75	Incomplete
PNR-519	02.90	05.00	09.16	2.50	4.85	7.23	32.65	47.25	98.66
China Boro	03.15	04.75	06.66	2.15	4.85	6.40	35.90	47.25	Incomplete
IET-13544	02.90	04.75	08.33	2.40	4.10	6.73	34.58	45.50	Incomplete
IET-4315	03.25	06.00	10.99	2.50	5.35	9.73	35.75	45.25	Incomplete
Dhansagar	02.75	04.25	07.29	2.00	4.60	7.90	36.30	46.65	Incomplete
UBSR-3	02.30	04.00	08.82	2.30	4.60	6.56	36.50	47.00	Incomplete
Mean	2.97	5.13	8.40	2.34	4.79	7.36	34.59	44.12	98.86
	Fecundity			Incubation			Larval-pupal period		
Interaction	V	S	V x S	V	S	V x S	V	S	V x S
SEm (±)	0.2646	0.0936	0.4583	0.1470	0.0520	0.2546	0.3297	0.1166	0.5711
CD (p=0.05)	0.5231	0.1849	0.9060	0.2906	0.1027	0.5033	0.6517	0.2304	1.1288

and being shortest (6.38 days) on Kanak followed by IR-68, Pusa Basmati and China Boro (6.40 days) .

In the present study, the longevity of females were more than males, which is at par with the observation made by Hansen et al. (2004) and Prakash et al. (1987). El-Nahal (1978) found negative correlation of adult longevity with temperature which also confirms present findings. Where, the period was recorded longer 8.40 days at 17.10^{0}C and 66.50% RH during December and being shorter 2.97 days at 25.49^{0}C and 73.91% RH during September and 5.13 days at 20.56^{0}C and 65% RH during October. However, Mandragon and Almeida (1988) reported 28.4 days at 20^{0}C and 15 days at 25^{0}C. Cangardel and Stockel (1972) observed life span of female was 4.5-6.8 days and for male 4.2-5.8 days. The result under present studies also showed

4.00-6.00 days for female at 20.56^{0}C and 65% RH and 4.10-5.35 days for male at 19.96^{0}C and 76.92% RH

3.5. Life cycle

Life cycle of S. cerealella was varied significantly with genotypes of paddy (Table 2). The longest period was recorded during winter (98.86 days) months while shortest period was recorded during post-monsoon months (34.59 days) and followed by autumn month (44.12 days). During post-monsoon and autumn S. cerealella completed its life cycle in 32.65-55.00 days which is at par with Germanov (1982), and Mondragon and Almeida (1988). The longest (39.40 days) period was recoded on Kanak followed by Sita (38.73 days) and IR-68 (38.06 days) while shortest (32.65 days) being on PNR-519, Sadabhog and Tulshi manjari (34.15 days) during post monsoon months. In autumn months the longest life cycle was recorded (55.00 days) on Nauda and shortest being 41.00 days on Tulsimanjuri followed by Kanak (41.75 days) and Tulsibhog (41.75 days). The total developmental period (egg-adult) was found incomplete in many varieties during winter months. The variety where total development was taken place, shortest and longest duration of life cycle was recorded 89.16 days and 103.25 days in UBSR-2 and Swarna Mashuri, respectively.

Correlation studies (Table 3) showed that all the biological parameters like fecundity, incubation period, larval-pupal period, adult longevity and duration of total life cycle were negatively correlated with maximum, minimum and average temperature and average RH% in three different seasons excepting female longevity which was positively related with average RH% confirms Rodriguez (1982) and Mendoza et al. (2004)

Table 3: Correlation of different developmental stages with climatic condition

1	2	3	4	5a	5b	6
Max temp	0.558	-0.761	-0.928	-0.991	-0.986	-0.869
Min temp	0.671	-0.878	-0.982	-0.997*	-0.991	-0.934
Avg temp	0.616	-0.826	-0.962	-0.985	-0.989	-0.906
Avg RH%	-0.381	0.588	0.729	-0.733	0.978	0.457

*Significant at 5%; 1: Climatic conditions; 2: Fecundity; 3: Incubation; 4: MDP; 5a: Adult longevity (female); 5b: Adult longevity (male); 6: Life cycle

4. Conclusion

From overall observation it can be said that the favorable season for the development of S. cerealella is post-monsoon months in this region under consideration when it takes only 34.59 days to complete one generation and the optimum climatic conditions is 26.68-29.23^{0}C and 66.16% RH. Among the different genotypes Tulsibhog and IR-50 were the most preferred for development and Sita, IR-68 and Mashuri were found to be unfavorable for development but with respect to fecundity Swarna Mashuri and China Boro were found to be the suitable one in this zone.

5. References

Al-khawass, K.A.M.H., 2010. Effect of some plant powders on the biology of *Sitotroga cerealella* Oliver (Lepidoptera: Gelichiidae) on wheat. Journal of Plant Protection and Pathology 1(11), 929-936.

Anand Prakash, M., Chhillar, B.S., Kashyap, R.K., 2004. Studies on the biology of Angoumois grain moth, *Sitotroga cerealella* (Oliver) (Lepidoptera: Gelechiidae) on wheat varieties. Indian Journal of Entomology 66(3), 264-286.

Cangardel, I.I., Stockel, J. ,1972. Investigations by means of laboratory rearing and sexual trapping on the annual cycle of the Angoumois grain moth *Sitotroga cerealella* Oliv. Annals de Zoologie Ecologie Animale 4(3), 311-323.

Champ, B.R., Dyte, C.E., 1977. FAO global survey of pesticide susceptibility of stored grain pests. FAO Plant Protection Bulletin 25, 49-67.

Chatterjii, S., 1953. Effect of humidity on some pests of stored cereals. Indian Journal of Entomology 15, 327-336.

El-Nahal, A.K., Ismail, I.I., Kamel, A.H., Moustafa, T.S., Nahal, A.K.El., 1978. Effect of temperature and relative humidity on the development of Sitotroga cerealella (Oliver) (Lepidoptera: Gelechiidae). In: Proceedings of 4th Conference on Pest Control, September 30-October 3, 148-155.

Germanov, A., 1982. Development and behavior of larvae of Angoumois grain moth (*Sitotroga cerealella* Oliv.) under conditions of mass rearing. Rasteniev'dni Nauki 19(5), 87-95.

Hansen, L.S., Skovgard, H., Hell, K., 2004. Life table study of Sitotroga cerealela (Lepidoptera: Gelichiidae), a strain from West Africa. Journal of Economic Entomology 97(4), 1484-1490.

Howe, R.W., 1971. A parameter for expressing the suitability of an environment fro insect development. Journal of Stored Products Research 7, 63-64.

Khanam, L.A.M., Malek, M.A., Parveen, B., Rahman, S.M., 1993. Extent of damage by *Sitotroga cerealella* (Oliv.) (Lepidoptera: Gelechiidae) to different cultivars of unhusked stored rice in Bangladesh. Annals of Entomology 8(2), 23-26.

Manojlovic, B., 1987. The influence of climatic factors and food on embryonic and postembryonic development of the angoumois grain moth Sitotroga cerealella Oliv. (Lepidoptera: Gelechiidae). Zastita Bilja 38(4), 325-336.

Mendoza, J.P., David, K., Weaver, I., Throne, J.E., 2004. Development and survivorship of immature Angoumois grain moth (Lepidoptera: Gelechiidae) on stored Corn. Environmental Entomology 33(4), 807-814.

Mondragon, I., Almedia, A.A., 1988. Influence of two temperatures on the development of *Sitotroga cerealella* (Oliv.) (Lepidoptera: Gelechiidae) on stored maize. Anais de Sociedade Entomologica do Brasil 17(2), 397-407.

Pandey, V., Pandey, N.D. ,1976. Growth and development of Sitotroga cerealella (Oliv.) on different varieties of maize. Indian Journal of Entomology 38(2), 125-129.

Pathak, K.A., Jha, A.N., 2003. Survey of insect pests of stored maize and paddy in north eastern region. Indian Journal of Entomology 65(1), 127-133.

Prakash, A., Rao, J., Pasalu, I.C., Mathur, K.C., 1987. Rice Storage and Insect Pest Management. B. R. Pub. Corporation. Delhi, 337.

Rai, A., 2003. Behavioural biology and susceptibility of Angoumois grain moth (*Sitotroga cerealella* Oliv.) to paddy grain. M.Sc. Thesis, Uttar Banga Krishi Viswavidyalaya, Pundibari, Cooch Behar, West Bengal, India.

Rodriguez, M.del.C., Pla, D., 1983. Influence of the relative humidity on oviposition by *Sitotroga cerealella* (Lepidoptera: Gelechiidae). Ciencia y Yecnicia en la Agricultura Protection de Plantas 6(2), 89-96.

Shahjahan,M., 1974. Extent of damage of unhusked stored rice by *Sitotroga cerealella* (Oliv.) Lepidoptera: Gelechiidae) in Bangladesh. Journal of Stored Product Research 10, 23-26.

Shazali, M.E.H., Smith, R.H., 1985. Life history studies of internally feeding pests of stored sorghum: *Sitotroga cerealella* (Oliv.) and *Sitophilus oryzae* (L.). Journal of Stored Product Research 21, 177-178.

Uttam, J.R., Verma, R.A., Singh, D.R., 2002. Studies on correlation between insect population of *Sitotroga cerealella* and *Rizopertha domonica* with percentage of damaged grain and loss in weight of different rice varieties. Indian Journal of Entomology 64(3), 279-282.