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Population dynamics of angoumois grain moth *Sitotroga cerealella* (Olivier) on cereals at room temperature

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Abstract
The experiment was conducted at Department of Entomology, Faculty of Crop Protection, Sindh Agriculture University Tandojam, during the year 2016 to record the population dynamics of Angoumois grain moth, *Sitotroga cerealella* (Olivier), fed on four cereals grains i.e. wheat, rice, millet and corn at room temperature. The results determined that maximum population 280.00, was recorded in wheat on 22-03-2016, while the minimum 5.18, was recorded on 08-03-2016 followed by rice 122.33, on 15-03-2016 and 6.33, was recorded on 24-05-2016. On the other hand, Millet showed highest population 433.33, was recorded on 15-03-2016, whereas the minimum 2.00, recorded on 17-05-2016. Such as, the Corn, recorded maximum population 242.33, of Angoumois grain moth was recorded on 15-03-2016, whereas the minimum 2.00, population recorded on 17-05-2016, respectively. The overall mean population in wheat, rice, millet and corn was noted as (80.93±27.20, 50.58±12.08, 70.55±34.09 and 41.22±19.16), in that order. It was concluded that maximum population was recorded in wheat followed by millet and rice and the minimum population was recorded in corn. Maximum weight loss (12.94±2.63) was recorded in wheat followed by (11.77±2.27 and 7.90±1.21), in millet and corn. While, minimum weight loss (4.70±0.97) was recorded for rice. Correlation analysis indicated that there was positive correlation of population fluctuation of different cereals i.e. wheat, rice, millet and corn (r^2=0.9534, 0.2442, 0.3111 and 0.3724) with maximum temperature, wheat, rice, millet and corn (r^2=0.9616, 0.1724, 0.1770 and 0.2769) with minimum temperature and wheat, rice, maillet and corn (r^2=0.9695, 0.0175, 0.1463 and 0.2709) with relative humidity, respectively.

Keywords: *Sitotroga cerealella*, temperature, population, weight, correlation

1. Introduction
Cereals are an important crop in the world because of human food habits which provides certain by products. Among these rice, millet, wheat and corn play a significant role in the economic constancy of many countries. The area under cereal cultivation in Sindh was 1678.6(000) hectares and the population was 6508.1 (0000) tones (GOP, 2011). Land under cereal production in Pakistan was last measured at 13389792 (hectares) in 2015. Cereals include wheat, rice, maize, barley, oats, rye, millet, sorghum, buckwheat, and mixed grains. During the storage period, these cereals are vulnerable to infestations by a variety of insects, especially grain moth, *Sitotroga cerealella* (Olivier), which has a cosmopolitan distribution and has displayed an affinity for rice varieties with different levels of resistance (Rizwana *et al.*, 2011) [1]. The Angoumois grain moth is considered as most important pest of stored agricultural products worldwide. Infestations of *S. cerealella* rise during storage, in pre harvest or post harvest. The larvae of *S. cerealella* attack a variety of kernel such as: corn, sorghum, wheat, soya bean, rice and paddy (Ukeh *et al.*, 2008) [2]. Angoumois grain moth, also known as the rice moth or paddy moth is one of the most dominant species in the stored paddy (Prakash *et al.*, 1984) [3]. Development of the pest could possibly be managed by altering nutritive and physical characteristics of cereal (Danjumma *et al.*, 2009) [4]. Danjumma *et al.* (2009) [4] reported that the *S. cerealella* attacks all types of cereal grains, particularly wheat where weight losses can be as much as 50%. The Angoumois grain moth, *S. cerealella* (Olivier) cosmopolitan pest of corn, wheat, rice, barley, sorghum and other cereals grains (Seifelnasr and Mills, 1985) [5]. This pest also damaged the crop under field conditions (Agrawal *et al*., 1977, Singh *et al*., 1978) [6]. The insect grow inside the kernels where they directly damaged the grain and make the suitable reproduction medium to reproduce their F1 generation

(Weston and Rattlingourd, 2000) [7]. The Angoumois grain moth, layed eggs single or clusters, hatched larvae deposited in kernels and cracks pericarp. In kernel, larval-pupal period finished and in silk-lined chamber they complete pupation. Life cycle varies with abiotic factors such as temperature and relative humidity (Arbogast and Mullen, 1987) [8]. Previous research reported that life cycle ranges from 25 days at 30^0C temperature and 70% RH (Shazali and Smith (1985) [9]. Overall 28 days from pupae to larval development period on at 30^0C temperature and 80% RH (Grewal and Atwal, 2015) [10]; however the pest takes maximum 36 days under ambient temperature from pupae to larval development. A number of researches have been carried out on S. cereals life cycle (Koone 1992) [11]. Keeping in view the above fact and figure we decide to carry out to record the influence of temperature and humidity on the population dynamics of Angoumois grain moth *S. cerealella* (Olivier) on cereals at room temperature. The main objectives of study were to record the weight loss, population dynamic of Angoumois grain moth with relative humidity and room temperature.

2. Materials and methods

The experiment was conducted at Department of Entomology, Faculty of Crop Protection, Sindh Agriculture University Tandojam, during the year of 2016, to record the population dynamics of Angoumois grain moth *s. cerealella* (olivier) on different cereals at room temperature. The following four cereals grains i.e. Wheat (*Triticum aestivum* L.), Rice (*Oryza sativa* L), Millet (*Pennisetum glaucoma* L) and Corn (*Zea Mays* L) were fed on *Sitotroga cerealella* (Olivier). The each grain of 250 grams were placed in the plastic jars covered with the muslin cloth and secure with rubber band. Each jar having different cereals contain 1 ml *S. cerealella* eggs for the emergence of pest. The treatments replicated three times having randomized complete design (RCD). Each jar was provided with the wet cotton ball to provide moisture for the emergence of the pest. The observations on population fluctuation were recorded on daily basis to assess the population growth and food preferences of Angoumois grain moth on different grains of cereal.

3. Statistical analysis

The data recorded on above characters were subjected to statistical analysis of variance following Gomez and Gomez (1984). The analysis of the data will be conducted by the means of Statistical Package 'Statistix' version 8.1 for personal computers.

4. Results

The data in table-1 denoted that maximum population was recorded (280.00) in wheat on 22-03-2016 having minimum-maximum temperature of 17.5-35.5ºC and relative humidity 40.85%, respectively. Minimum (5.18) population was found on 08-03-2016 having minimum-maximum temperature (15.5-31.5ºC) and relative humidity (54.14%), respectively. The perusal of the data further indicates that the overall mean population was recorded as (80.93±27.20). The ANOVA shows that there was highly significant (P<0.001**; DF=11; F-value=45.67) difference in Angoumois grain moth population on all observational dates.

Regarding rice the maximum population (122.33) was recorded on 15-03-2016 having minimum-maximum temperature (18.0-35.5ºC) and relative humidity (49.85%), respectively and minimum population (6.33) were recorded on 24-05-2016 having minimum-maximum temperature (26.0-40.5ºC) and relative humidity (50%), respectively as shown in Table-2. Furthermore, overall mean population was recorded as (50.58±12.08). The ANOVA shows that there was significant (P<0.001**; DF=11; F-value=24.10) difference in Angoumois grain moth population on all observational dates.

In millet the maximum population (433.33) was recorded on 15-03-2016 having minimum-maximum temperature (18.0-35.5ºC) and relative humidity (49.85%), respectively. Minimum (2.00) population in millet were recorded on 17-05-2016 having minimum-maximum temperature (24.5-45.5ºC) and relative humidity (47.71%), respectively as denoted in Table-3. However, overall mean population was recorded as (70.55±34.09). The ANOVA shows that there was significant (P<0.001**; DF=11; F-value=38.60) difference in Angoumois grain moth population on all observational dates.

Table-4 signify the maximum population (242.33) in corn on 15-03-2016 having minimum-maximum temperature (18.0-35.5ºC) and relative humidity (49.85%), respectively. While, minimum (2.00) population in corn were recorded on 17-05-2016 having minimum-maximum temperature (24.0-45.5ºC) and relative humidity (47.71%), respectively. The perusal of the data shows that overall mean population was recorded as (41.22±19.16). The ANOVA shows that there was significant (P<0.001**; DF=11; F-value=110.17) difference in Angoumois grain moth population on all observational dates.

Table-5 demonstrated the maximum weight loss (12.94±2.63) in wheat followed by (11.77±2.27 and 7.90±1.21) in millet and corn. While, minimum weight loss (4.70±0.97) was recorded for rice. The ANOVA shows that there was significant (P<0.0204*; DF=3; F-value=3.61) difference in weight loss between different cereals by Angoumois grain moth on all observational dates.

Table 1: Population fluctuation of Angoumois grain moth on wheat from 08-03-2016 to 24 05-2016

Dates	Population fluctuation	Temperature		Relative humidity
		Minimum	Maximum	
08-03-2016	5.18	15.5	31.5	54.14
15-03-2016	128.00	18	35.5	49.85
22-03-2016	280.00	17.5	35.5	40.85
29-03-2016	208.33	15	37	39.71
05-04-2016	176.00	18.5	35.5	48
12-04-2016	65.00	19.5	39.0	44.71
19-04-2016	40.33	20.5	38.5	47.14
26-04-2016	21.67	23.0	41.5	40.28

03-05-2016	24.33	33.5	40.0	41.00
10-05-2016	8.00	25.0	40.0	50.14
17-05-2016	8.67	24.5	45.5	47.71
24-05-2016	5.67	26.0	40.5	50.00
Mean±SE	80.93±27.20	21.37 ± 1.52	38.33 ± 1.04	45.80± 1.99

Table 2: Population fluctuation of Angoumois grain moth on rice from 08-03-2016 to 24-05-2016

Dates	Population fluctuation	Temperature		Relative humidity
		Minimum	Maximum	
08-03-2016	93.67	15.5	31.5	54.14
15-03-2016	122.33	18	35.5	49.85
22-03-2016	24.67	17.5	35.5	40.85
29-03-2016	26.67	15	37	39.71
05-04-2016	57.00	18.5	35.5	48
12-04-2016	113.33	19.5	39.0	44.71
19-04-2016	83.00	20.5	38.5	47.14
26-04-2016	33.67	23.0	41.5	40.28
03-05-2016	18.33	33.5	40.0	41.00
10-05-2016	9.33	25.0	40.0	50.14
17-05-2016	18.67	24.5	45.5	47.71
24-05-2016	6.33	26.0	40.5	50.00
Mean±SE	50.58±12.08	21.37± 1.52	38.33±1.04	45.80±1.99

Table 3: Population fluctuation of Angoumois grain moth on millet from 08-03-2016 to 24-05-2016

Dates	Population fluctuation	Temperature		Relative humidity
		Minimum	Maximum	
08-03-2016	78.33	15.5	31.5	54.14
15-03-2016	433.33	18	35.5	49.85
22-03-2016	61.66	17.5	35.5	40.85
29-03-2016	33.00	15	37	39.71
05-04-2016	19.66	18.5	35.5	48
12-04-2016	45.33	19.5	39.0	44.71
19-04-2016	94.00	20.5	38.5	47.14
26-04-2016	46.66	23.0	41.5	40.28
03-05-2016	29.33	33.5	40.0	41.00
10-05-2016	3.33	25.0	40.0	50.14
17-05-2016	2.00	24.5	45.5	47.71
24-05-2016	0.00	26.0	40.5	50.00
Mean±SE	70.55±34.09	21.37±1.52	38.33±1.04	45.80±1.99

Table 4: Population fluctuation of Angoumois grain moth on corn from 08-03-2016 to 24-05-2016

Dates	Population fluctuation	Temperature		Relative humidity
		Minimum	Maximum	
08-03-2016	66.66	15.5	31.5	54.14
15-03-2016	242.33	18	35.5	49.85
22-03-2016	53.33	17.5	35.5	40.85
29-03-2016	30.33	15	37	39.71
05-04-2016	20.33	18.5	35.5	48
12-04-2016	20.00	19.5	39.0	44.71
19-04-2016	26.00	20.5	38.5	47.14
26-04-2016	15.66	23.0	41.5	40.28
03-05-2016	12.00	33.5	40.0	41.00
10-05-2016	6.00	25.0	40.0	50.14
17-05-2016	2.00	24.5	45.5	47.71
24-05-2016	0.00	26.0	40.5	50.00
Mean±SE	41.22±19.16	21.37±1.52	38.33±1.04	45.80±1.99

Table 5: Weight loss (gm) in different cereals by Angoumois grain moth from 08-03-2016 to 24-05-2016

Dates	Wheat	Rice	Millet	Corn
08-03-2016	20.76	1.00	17.33	9.00
15-03-2016	24.91	0.33	14.00	10.00
22-03-2016	24.66	6.67	19.00	10.67
29-03-2016	18.80	8.67	24.00	9.33
05-04-2016	17.44	9.73	20.90	13.10

12-04-2016	16.96	8.37	16.37	14.13
19-04-2016	10.00	7.73	10.83	10.47
26-04-2016	7.37	4.43	6.00	6.47
03-05-2016	4.37	3.87	6.14	5.00
10-05-2016	2.63	2.60	3.03	3.06
17-05-2016	1.33	1.93	2.47	2.34
24-05-2016	0.70	1.14	1.26	1.30
Mean±SE	12.94±2.63	4.70±0.97	11.7±2.27	7.90±1.21

Correlation analysis indicates that there was positive correlation of population fluctuation of different cereals i.e. wheat, rice, millet and corn (r^2=0.9534, 0.2442, 0.3111 and 0.3724) with temperature (minimum), wheat, rice, millet and corn (r^2=0.9616, 0.1724, 0.1770 and 0.2769) with temperature (maximum) and wheat, rice, millet and corn (r^2=0.9695, 0.0175, 0.1463 and 0.2709) with relative humidity as shown in Table-6.

Table 6: Correlationship with respect to population fluctuation of different cereals on Angoumois grain moth on temperature and relative humidity

Variables	Wheat	Rice	Millet	Corn
Temp. Maximum	0.9534	0.2442	0.3111	0.3724
Temp. Minimum	0.9616	0.1724	0.1770	0.2769
Relative humidity	0.9695	0.0175	0.1463	0.2709

5. Discussion

The results indicated that overall mean population in wheat, rice, millet and corn was recorded as (80.93±27.20, 50.58±12.08, 70.55±34.09 and 41.22±19.16), respectively. Similarly, these findings are agree with Hamed *et al*. (2012) noted that maximum population (76.0%) F1 generation was observed in sorghum followed by 75.3, 70.0, 50.8, 67.6 and 40.8% in wheat, oat, millet, barley and rice. Minimum Population (42.0%) of F1 generation was observed in corn. The present data showed in table (1) that maximum population was recorded (280.00) in wheat on 22-03-2016, minimum (5.18) population was found on 08-03-2016 having minimum-maximum temperature (15.5-31.5ºC) and relative humidity (54.14%). Our agreements are agreed those findings are supported by Khan *et al.* (2010) reported that in twelve wheat genotypes the damage and losses caused by *S. cerealella* varied from 19.28 – 58.29% and 12.19 – 40.93% respectively. Regarding in table (2) that maximum population rice (122.33) was recorded on 15-03-2016 having minimum-maximum temperature (18.0-35.5ºC) and relative humidity (49.85%), respectively. These findings are not agreed with Rustamani *et al.* (2014) concluded that T. castaneum caused heavy losses in rice with maximum (272.25 beetles) population at (24-45ºC) followed by (65.88 beetles) in semolina, (8.5 beetles) in corn flakes and (6.16 beetles) in biscuits. There was positive and significant correlation of abiotic factors with pest population. The present data reveled in table-5 demonstrated that the maximum weight loss (12.94±2.63) in wheat followed by (11.77±2.27 and 7.90±1.21) in millet and corn. While, minimum weight loss (4.70±0.97) was recorded in rice. Our results are generally agreed with Ahmad-Ur-Rahman *et al.* (2015) who determined that the cultivar 'Fakhre Sarhad' were more tolerant with weight loss (3.87%) compared to 7.61, 7.78, 9.19 and 9.75% for Uqab, Sehar, Shafaq and Dera-98, respectively. Similarly, Hassan *et al.* (1994) reported that weight loss due to insect pests in Multan and Bahawalpur ranged between 0.45-0.72percent. As well as investigation of Rizwana *et al.* (2011) concluded that there is no variety was completely immune to the infestation of this pest, and Basmati-Pak & G-7 were highly susceptible and significantly different from all other varieties. On the basis of percent weight losses in present studies therefore, Basmati-Pak and G-7 were highest susceptible cultivars showing 25.4 and 25.0 %, while Basmati-2000 with 23.00% weight loss. IRRI- 6 and G-6 were at par with 20.2 and 20.1 % weight losses, respectively. The variety PK-Basmati-385 loosed weight as 18.2 %, Super Kernel Basmati as 7.8 and Basmati-370 as 6.2. Table-4 signified that maximum population (242.33) in corn on 15-03-2016 having minimum-maximum temperature (18.0-35.5ºC) and relative humidity (49.85%), respectively. According to Foaud (2013) reported the susceptibility of 05 varieties of corn against *S. cerealella* results showed that cultivar 'AG1501' shown maximum period of development, minimum percentage of survival and less weight loss, respectively instead of all other tested cultivars at all tested temperatures 15-35ºC, there was positive and significant interrelationship of pest population with corn cultivars.

6. Conclusions

On the basis of present findings, it was concluded that *S. cerealella* mostly prefer wheat followed by millet, corn and rice. As insect infestation is directly proportional to the abiotic factors, so the insect population found to be maximum when the temperature and relative humidity is favourable for the infestation. It is suggested that the Farmer's Community placed the cereal grain in a cool and dry place, to avoid the insect infestation.

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