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Impact of Abiotic Factors on the Growth and Development of *Corcyra cephalonica* Stainton in Stored Maize

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A B S T R A C T

An experiment was conducted in the laboratory to find out the impact of temperature and relative humidity on growth and development of *C. cephalonica* during, 2010-2011, revealed that the development period of male and female was maximum with a mean of 89.50 and 92.00 days at 20°C temperature and 40 per cent relative humidity, respectively. The maximum larval period of (70.10 days) was recorded at 20°C temperature and 40 per cent relative humidity; whereas, the maximum weight of full grown larva (51.00 mg) was recorded at 30°C temperature and 80 per cent relative humidity. The maximum pupal period of male (13.60 days) and female (14.40 days) were observed at 20°C temperature and 40 per cent relative humidity, while the higher weight of male (36.00 mg) and female (38.00 mg) pupa were observed at 30°C temperature and 80 per cent relative humidity. The maximum adult emergence of male (61.40%) and female (80.90%) were observed at 30°C temperature and 80 per cent relative humidity; whereas, the maximum adult longevity of male (16.30 days) and female (10.50 days) were observed at 20°C temperature and 40 per cent relative humidity. The maximum growth rate index of male (1.35) and female (1.64) were recorded at 30°C temperature and 80 per cent relative humidity, while minimum growth rate index male (0.39) and female (0.60) were observed at 20°C temperature and 40 per cent relative humidity.

Introduction

Maize (*Zea mays* L) is one of the most versatile emerging crops having wider adaptability under varied agro-climatic conditions. Globally, maize is known as queen of cereals because it has the highest genetic yield potential among the cereals. It is cultivated on nearly 150 m ha in about 160 countries having wider diversity of soil, climate, biodiversity and management practices. The average productivity in India is 2.5 tone/ ha (IMS, 2014). In India, maize is the third most important food crops after rice and wheat. Maize in India, contributes nearly 9 per cent in the national food basket. In addition to staple food for human being and quality feed for animals, maize serves as a basic raw material as an ingredient to thousands of industrial products that includes starch, oil, protein, alcoholic beverages, food sweeteners, pharmaceutical, cosmetic, film, textile, gum, package and paper industries etc. The maize is cultivated throughout the year in all states of the country for various purposes including grain, fodder, green cobs, sweet

corn, baby corn and pop corn in peri-urban areas. The predominant maize growing states that contributes more than 80 per cent of the total maize production are Andhra Pradesh (20.9 %), Karnataka (16.5 %), Rajasthan (9.9 %), Maharashtra (9.1 %), Bihar (8.9 %), Uttar Pradesh (6.1 %), Madhya Pradesh (5.7 %) and Himachal Pradesh (4.4 %). Apart from these states maize is also grown in Jammu and Kashmir and North-Eastern states. In Rajasthan, maize is mostly grown in Banswara, Udaipur, Bhilwara, Dungarpur, Rajsamand and Chittorgarh districts.

Although, there are about 200 species of insects and mites are found infesting maize grains, few of which are major or primary pests. Among these, the rice moth, *Corcyra cephalonica* (Stainton) (Lepidoptera: Pyralidae) is one of the most important pest of stored maize. *Corcyra cephalonica* (Stainton), popularly known as the "Rice meal moth" or the "flour moth". The earlier reference of this insect was made by Stainton (1866), who provisionally named it *Melissoblaptes cephalonica* giving a brief description. Later a new genus, *Corcyra* was erected by Rogonot (1885) to accommodate this insect, the name being derived from the ancient name of "Corfu", where it was presumed to have been imported into England. According to Chittenden (1919), though Corcyra is known to occur many parts of Europe, Asia and America. It feeds on many hosts, viz., rice, sorghum, wheat, groundnut, gram, cotton seed, etc. The larvae cause damage to grain by feeding under silken webs. When infestation is high the entire stock of grain may converted into a webbed mass. Ultimately, a characteristic fowl odour is developed and the grain rendered unfit for human consumption. The pest cause both quantitative and qualitative losses.

In order to develop economic and effective control measures for *C. cephalonica*, detailed and accurate knowledge of its bio-ecology is essential under variable macro-ecological conditions which would be helpful in the possible prediction of population levels and study the various mortality factors regulating pest abundance so that an effective management strategy may be developed. These aspects need more intensive investigations, as abiotic factors such as temperature, relative humidity and moisture percentage of stored products play vital role in pest infestation. Temperature mediated physiological actions regulate population dynamics. The effect of humidity on the development of host insect is almost intimately associated with that of temperature and operations indirectly through the moisture content of grains. These parameters ultimately shows their effect on the feeding ability and getting good quality eggs through enhanced nourishment of Corcyra larvae. One of the eco-friendly and economic approaches to keep the stored food grains free from insect attack, thus the present study were undertaken to find out the role of different temperature and the relative humidity levels and their combined effect on some biological parameters of *C. cephalonica*.

Materials and Methods

The present experiment was carried out on mainly two parameters *i.e.*, temperature and relative humidity under laboratory conditions for their effect on growth and development of *C. cephalonica* at Bio-control Research Laboratory, Department of Entomology, Rajasthan College of Agriculture, MPUAT, Udaipur during 2010. Biological studies of *C. cephalonica* were undertaken at three different temperatures and humidity levels. Two hundred gram conditioned maize grain as described in the maintenance of insect culture were taken in plastic containers (230x75mm). Twenty newly hatched larvae of *C. cephalonica* were released in containers.

These containers were kept in different BOD incubators, which were fixed temperatures of 20^0C, 30^0C and 40^0C with variable relative humidity *i.e.* 40, 60, 80 per cent. Every day grains were checked. Observations were recorded on developmental period (body weight, larval and pupal period), adult emergence (male and female), adult longevity and growth rate index. In order to obtain eggs, to study the development period, the folded black thick papers were introduced into culture jars containing 1 to 2 days old *C. cephalonica* adult moths. After 24 hours, the black thick papers were removed and unfolded. The black thick paper bearing 50 eggs was cut and kept in petri dish. The pieces of black paper were removed from the petri dish and the eggs were carefully examined for hatching under a binocular microscope. The incubation period worked out by recording the date of egg laying and date of egg hatching. The freshly hatched larvae were released in each replication for the study of development of *C. cephalonica* and observations were continued till the adult emergence ceased. The larval period was worked out by recording the date of hatching and date of formation of silken web in the food. The period between web formation and adult emergence was considered as pupal period. Larval and pupal weight was determined with help of electronic balance. Longevity of male and female adults was determined by recording the date of their emergence from pupae and the date of natural death. The growth rate index was worked out with the help of following formula:

$$\text{Growth Rate Index} = \frac{\text{Percent adult emergence}}{\text{Total development period}}$$

Results and Discussions

Temperature is an important component of the environment and the rate of metabolism, growth, development, reproduction, general behavior and distribution of insect pests are largely controlled by it. Fields (1992) proposed lethal, sub-lethal and optimal temperature ranges for many stored product insects; 25-33°C is optimal for growth and reproduction, while; 13-25°C or 33-35°C are sub-optimal at which insects are able to complete their development and produces offspring, and lastly at < 13° or > 35°C insects eventually die. Changes in metabolic rate caused by fluctuations of temperature have a direct bearing on two important aspects of insect life cycles; one is locomotion for performing crucial activities such as mating and feeding and the other is growth represented by development and metamorphosis. Thus, temperature mediated physiological actions regulate population dynamics. The effect of humidity on the development of storage pest is almost intimately associated with that of temperature and operates indirectly through the moisture content of grains. With regard to biology, reproductive potentiality and development of *C. cephalonica* some work has been carried out on different temperatures and relative humidities in different countries of the world (Kamel and Hassanein, 1967; Teotia and singh, 1975; pajni *et al*., 1978; Meena and Bhargava, 2010 and Chaubey and Misra, 2011).

Developmental period of female and male

The data on the effect of temperature and relative humidity interaction of both the factors on the development period of female and mele have been presented in table 1. The development period of test insect varied with the temperature. The development period was maximum of 87.53 days at 20°C and minimum of 42.83 days was recorded at 40°C temperature. The data obtained on the effect of relative humidity revealed that the test insect took maximum 67.13 days to complete

their development at 40 per cent relative humidity and it was minimum of 52.57 days at 80 per cent relative humidity. The present studies on effect of temperature and relative humidity revealed that the developmental period of *C. cephalonica* was 92.00 days at 20°C temperature and 40 per cent relative humidity. Whereas, the minimum development period of the test insect 31.30 days was recorded at 40°C temperature and 80 per cent relative humidity. The maximum development period of male *i.e.* 84.60 days was recorded at 20°C and minimum 40.00 days was recorded at 40°C temperature. The data obtained on the effect of relative humidity revealed that the test insect took maximum 64.40 days to complete their development at 40 per cent relative humidity and it was minimum of 49.30 days at 80 per cent relative humidity. The present studies on effect of temperature and relative humidity revealed that the developmental period of *C. cephalonica* was 89.50 days at 20°C temperature and 40 per cent relative humidity. Whereas, the minimum development period of the test insect 33.70 days was recorded at 40°C temperature and 80 per cent relative humidity. This finding is in close conformity with the findings of Jagdish *et al.,* (2009) reported the total developmenatal period of *C. cephalonica* occupied, 41 to 59 days on foxtail millet at a temperature of 24-28°C and 70% relative humidity. Russell *et al.,* (1980) reported that at 70 per cent relative humidity and 28°C temperature, developmental period were 40 and 41 days for males and females, respectively. Allotey and Azalekor (2000) observed that at temperature ranging from 27.5-30°C and relative humidity from 60-73 per cent the mean developmental period ranged from 33.2 ± 0.2 to 45.3 ± 1.8 days. Similarily, the mean developmental period of *C. cephalonica* ranged from 46.5 to 77 days at 25.5°C temperature and 75 per cent relative humidity this finding was also supported by Kamel and Hassanein (1967). reported that mean larval period was 66.40 days at 15°C which it was lowest of 24.5 days at 30°C temperature.

Larval period

The influences of temperature and relative humidity on larval development have been presented in (Table 2) revealed that the larva period was maximum of 63.73 days at 20°C and it was minimum of 33.90 days at 40°C temperature. The data obtained on the effect of relative humidity revealed that the test insect took maximum 57.05 days to complete their larval period at 40.per cent relative humidity and minimum 38.60 days was taken by the test insect to complete their larval period at 80 per cent relative humidity. The present studies on effect of temperature and relative humidity revealed that the maximum larval period of *C. cephalonica i.e.* 70.10 days was at 20°C temperature and 40 per cent relative humidity, Whereas, the minimum larval period of the test insect 22.70 days was recorded at 40°C temperature and 80 per cent relative humidity. This finding is in close conformity with the findings of Hugar and jai rao (1985**)** found highest larval period 66.40 days at15°C lowest larval period 24.50 days at 30°C temperature.

Weight of full grown larva

Results obtained with regard to weight of full grown larvae at different levels of temperature and relative humidity have been presented in table 3. The larval weight found to be highest 46.33 mg. when the insect was reared at 30°C and lowest larval weight of 37.00 mg. was observed at 20°C temperature. The data obtained on the effect of relative humidity revealed that the maximum larval weight of 44.67 mg was recorded at 80 per cent relative humidity and minimum 38.33 mg was observed at 40 per cent relative humidity. The combined effect of temperature

and relative humidity showed that most suitable combination for weight of full grown larva was 30°C temperature and 80 per cent relative humidity on which maximum weight of 51.00 mg was recorded. While, the lowest larval weight 33.00 mg. was observed at 20°C temperature and 40 per cent relative humidity. Similar results were also obtained by Meena and Bhargava 2010 found that temperature of 30°C and relative humidity 70 per cent was the most suitable combination of which maximum weight of full grown larva (0.09 g.) was recorded.

Pupal Period of female and male

The data obtained on the effect of temperature and relative humidity on the duration of pupal stage of female and male have been presented in table 4. The pupal period of female varied with the temperature. The maximum pupal period of 13.40 days of female was found at 20°C and minimum of 10.50 days at 30°C temperature. The data obtained on the effect of relative humidity revealed that the test insect took maximum 12.60 days to complete their pupal period at 40 per cent relative humidity, while minimum 10.78 days was observed at 80 per cent relative humidity. The present studies on effect of temperature and relative humidity revealed that the maximum pupal period of *C. cephalonica* 14.40 days was observed at temperature 20°C and 40 per cent relative humidity, Whereas, the minimum pupal period of the test insect *i.e.* 9.85 days was recorded at 30°C temperature and 80 per cent relative humidity. The pupal period of male also varied with the temperature. The pupal period of male was maximum of 12.30 days at 20°C and it was minimum of 9.27 days at 30°C temperature. The data obtained on the effect of relative humidity revealed that the test insect took maximum 11.67 days to complete their pupal period at 40 per cent relative humidity and minimum 9.80 days was observed at 80 per cent relative humidity. The present studies on effect of temperature and relative humidity revealed that the maximum pupal period of *C. cephalonica* 13.60 days was observed at temperature 20°C and 40 per cent relative humidity, Whereas, the minimum pupal period of the test insect *i.e.* 8.40 days was recorded at 30°C temperature and 80 per cent relative humidity. This finding is in close conformity with the findings of Ray (1994). reported that the pupal period of *C. cephalonica* on maize at 28±1°C and RH 75 per cent was recorded 10 days. Hugar *et al*., (1990) reported that the pupal period decreased with increase in temperature and humidity, being longest at 15°C and shortest at 35°C.

Pupal weight of female and male

The mean weight of mature pupa recorded at different temperture and relative humidity have been presented in table 5 the data revealed that the higher pupal weight 35.67 mg of female pupae was recorded when the insect was reared at 30°C and it was lowest of 25.67 mg at 20°C temperature. The data obtained on the effect of relative humidity revealed that the mean pupal weight was maximum of 33.33 mg at 80 per cent relative humidity and was minimum *i.e.* 28.33 mg at 40 per cent relative humidity. The combined effect of temperature and relative humidity showed that most suitable combination for gaining the higher weight of pupa was 30°C temperature and 80 per cent relative humidity at which maximum weight of 38.00 mg was recorded. Lowest pupal weight of 23.00 mg was observed at 20°C temperature and 40 per cent relative humidity. The pupal weight of male was highest of 33.00 mg when the insect was reared at 30°C and it was lowest of 23.00 mg at 20°C temperature. The data obtained on the effect of relative humidity revealed that the mean pupal weight was maximum of 31.00 mg at 80 per cent relative humidity and

was minimum *i.e.* 26.00 mg at 40 per cent relative humidity. The combined effect of temperature and relative humidity showed that most suitable combination for gaining the higher weight of pupa was 30°C temperature and 80 per cent relative humidity at which maximum weight of 36.00 mg was recorded. Lowest pupal weight of 21.00 mg. was observed at 20°C temperature and 40 per cent relative humidity. Similar findings were also reported by Meena and Bhargava (2010) and reported that a combination of 30°C temperature and 70 per cent was most suitable for the pupa to gain optimum weight.

Adult emergence of female and male

The data presented in table 6 showed that the maximum adult emergence of female was recorded (72.90%) when insects were reared at 30°C and minimum adult emergence (60.67%) was observed at 20°C temperature. The data obtained on the effect of relative humidity revealed that the maximum adult emergence (71.92%) was at 80 per cent relative humidity and it was minimum (59.20%) at 40 per cent relative humidity. The combined effect of temperature and relative humidity showed that a combination 30°C temperature and 80 per cent relative humidity was most suitable at which maximum adult emergence (80.90%) was observed, while minimum adult emergence (54.90%) was observed at 20°C temperature and 40 per cent relative humidity. The maximum 53.40 per cent and minimum adult emergence 39.73% was recorded when insect was reared at 30°C and 20°C temperature, respectively. The data obtained on the effect of relative humidity revealed that the maximum (52.20%) and minimum adult emergence (40.23%) was recorded at 80 per cent and 40 per cent relative humidity, respectively. The combined effect of temperature and relative humidity showed that a combination 30°C temperature and 80 per cent relative humidity was most suitable at which maximum adult emergence (61.40%) was observed. While, minimum adult emergence (35.10%) was observed at 20°C temperature and 40 per cent relative humidity. These observations are in conformity with the findings of Hugar *et al*., (1990). He reported that maximum adult emergence at optimum temperature (25 - 30°C) and least at 15°C and it was less pronounced by relative humidity. Allotey and Azalekor (1999) reported 67.5 per cent adult emergence at 27-30°C and 60-73 per cent relative humidity.

Longevity of male and female adult

The longevity of male and female adults recorded at different levels of temperature and relative humidity have been present in table 7 reveals that the longevity of male and female adults indicate that it increases with the decrease in temperature. The maximum longevity of male and female of 12.83 and 9.92 days was recorded at 20°C temperature, respectively. Longevity of male and female adults was Minimum of 3.16 and 2.99 days, respectively at 40°C temperature.

The humidity also seemed to have effect on the longevity of male and female adults whereas maximum longevity of male and female 8.89 and 6.30 days was observed at 40 per cent relative humidity, respectively, whereas minimum longevity of male and female 6.32 and 5.60 at 80 per cent relative humidity, respectively. The effect of both factors on longevity of male and female adults showed that the longevity of adult was maximum at 20°C and 40 per cent relative humidity combinations, and it was minimum at 40°C and 60 per cent relative humidity. This finding is in close conformity with the findings of Cox *et al.,* (1981) reported that the life span of *C. cephalonica* increased with decreasing temperature between 20 and 35°C.

Table.1 Effect of temperature and relative humidity on the development of *C. cephalonica*

Relative humidity (%)	Developmental period (days)							
	Female				Male			
	Temperature (°C)			Mean	Temperature (°C)			Mean
	20	30	40		20	30	40	
40	92.00	56.30	53.10	67.13	89.50	53.40	50.30	64.40
60	90.30	36.56	44.10	56.99	87.40	35.10	36.00	52.83
80	80.30	46.10	31.30	52.57	76.90	37.30	33.70	49.30
Mean	87.53	46.32	42.83		84.60	41.93	40.00	
S.Em. ±	**0.877**				**0.876**			
C.D. (P=0.05)	**2.546**				**2.543**			

Table.2 Effect of temperature and relative humidity on the larval period of *C. cephalonica*

Relative humidity (%)	Larval period (days)			
	Temperature (°C)			Mean
	20	30	40	
40	70.10	55.85	45.20	57.05
60	65.10	24.60	33.80	41.17
80	56.00	37.10	22.70	38.60
Mean	63.73	39.18	33.90	
S.Em. ±	**1.361**			
C.D. (P=0.05)	**3.949**			

Table.3 Effect of temperature and relative humidity on weight of full grown larva of *C. cephalonica*

Relative humidity (%)	Weight of full grown larva (mg)			
	Temperature (°C)			Mean
	20	30	40	
40	33.00	42.00	40.00	38.33
60	38.00	46.00	41.00	41.67
80	40.00	51.00	43.00	44.67
Mean	37.00	46.33	41.33	
S.Em. ±	**0.726**			
C.D. (P=0.05)	**2.106**			

Table.4 Effect of temperature and relative humidity on the pupal period of *C. cephalonica*

Relative humidity (%)	Pupal period (days)							
	Female				Male			
	Temperature (°C)			Mean	Temperature (°C)			Mean
	20	30	40		20	30	40	
40	14.40	11.29	12.10	12.60	13.60	10.30	11.10	11.67
60	13.50	10.35	11.30	11.72	12.10	9.10	10.30	10.50
80	12.30	9.85	10.20	10.78	11.20	8.40	9.80	9.80
Mean	13.40	10.50	11.20		12.30	9.27	10.40	
S.Em. ±	0.205				0.187			
C.D. (P=0.05)	0.594				0.542			

Table.5 Effect of temperature and relative humidity on pupal weight of *C. cephalonica*

Relative humidity (%)	Pupal weight (mg)							
	Female				Male			
	Temperature (°C)			Mean	Temperature (°C)			Mean
	20	30	40		20	30	40	
40	23.00	34.00	28.00	28.33	21.00	31.00	26.00	26.00
60	25.00	35.00	31.00	30.33	22.00	32.00	27.00	27.00
80	29.00	38.00	33.00	33.33	26.00	36.00	31.00	31.00
Mean	25.67	35.67	30.73		23.00	33.00	28.00	
S.Em. ±	0.538				0.493			
C.D. (P=0.05)	1.560				0.142			

Table.6 Effect of temperature and relative humidity on the adult emergence of *C. cephalonica*

Relative humidity (%)	Adult emergence (%)							
	Female				Male			
	Temperature (°C)			Mean	Temperature (°C)			Mean
	20	30	40		20	30	40	
40	54.90 (47.81)	62.70 (52.36)	60.00 (50.77)	59.20 (50.31)	35.10 (36.33)	42.60 (40.74)	43.00 (40.98)	40.23 (39.34)
60	62.30 (52.13)	75.10 (60.08)	71.40 (57.69)	69.60 (56.63)	41.52 (40.12)	56.20 (48.56)	52.30 (46.32)	50.07 (45.00)
80	65.10 (53.80)	80.90 (64.09)	69.75 (56.63)	71.92 (58.17)	42.56 (40.72)	61.40 (51.59)	54.50 (47.58)	52.82 (46.63)
Mean	60.67 (51.25)	72.90 (58.84)	67.05 (55.03)		39.73 (39.05)	53.40 (46.97)	49.93 (44.96)	
S. Em. ±	0.541				0.359			
C.D. (P=0.05)	1.570				1.041			

Figure in parenthesis shows the angular transformed values of the respective values

Table.7 Effect of temperature and relative humidity on adult longevity of *C. cephalonica*

Relative humidity (%)	Adult longevity (Days)							
	Female				Male			
	Temperature (°C)			Mean	Temperature (°C)			Mean
	20	30	40		20	30	40	
40	10.50	5.20	3.20	6.30	16.30	7.10	3.28	8.89
60	10.00	5.00	2.95	5.98	14.20	6.80	3.15	8.05
80	9.25	4.75	2.81	5.60	8.00	7.80	3.05	6.28
Mean	9.92	4.98	2.99		12.83	7.23	3.16	
S. Em. ±	**0.242**				**0.256**			
C.D. (P=0.05)	**0.701**				**0.744**			

Table.8 Effect of temperature and relative humidity on Growth Rate Index of *C. cephalonica*

Relative humidity (%)	Growth Rate Index							
	Female				Male			
	Temperature (°C)			Mean	Temperature (°C)			Mean
	20	30	40		20	30	40	
40	0.60	1.11	1.13	0.95	0.39	0.80	0.86	0.68
60	0.69	1.85	1.78	1.44	0.48	1.60	1.45	1.18
80	0.81	1.96	1.93	1.57	0.55	1.65	1.62	1.27
Mean	0.70	1.64	1.61		0.47	1.35	1.31	
S.Em. ±	**0.018**				**0.017**			
C.D. (P=0.05)	**0.054**				**0.049**			

Growth Rate Index of female and male

The data recorded on the individual and combined effect of the temperature and relative humidity on the growth rate index of *C. cephalonica* have been presented in table 8 revealed that the Growth Rate Index of female varied with temperature and relative humidity. The growth rate index was maximum *i.e.* 1.64 at 30°C and minimum 0.70 at 20°C temperature. The data obtained on the effect of relative humidity revealed that the maximum Growth Rate Index of 1.57 was recorded at 80 per cent relative humidity and minimum *i.e.* 0.95 was observed at 40 per cent relative humidity. The present studies on effect of temperature and relative humidity revealed that the maximum growth rate index of *C. cephalonica i.e.* 1.96 was observed at 30°C temperature and 80 per cent relative humidity. Whereas, the minimum Growth Rate Index of the test insect *i.e.* 0.60 was recorded at 20°C temperature and 40 per cent relative humidity. The Growth Rate Index of male also varied with temperature and relative humidity. The Growth Rate Index of male was maximum *i.e.* 1.35 at 30°C and was minimum of 0.0.47 at 20°C temperature. The data obtained on the effect of relative humidity revealed that the maximum Growth Rate Index of 1.27 was recorded at 80 per cent relative humidity and minimum *i.e.* 0.68 was observed at 40 per cent relative humidity. The present studies on effect of temperature and relative humidity revealed that the maximum Growth Rate Index of *C. cephalonica i.e.* 1.65 was observed at 30°C temperature and 80 per cent relative humidity. Whereas, the minimum Growth Rate Index of the test insect *i.e.* 0.39 was recorded at 20°C temperature and 40 per cent relative humidity. This finding is in close conformity with the

findings of Cheema *et al*, 1988. reported that the Growth Rate Index was greatest for larvae of *C. cephalonica* when it was reared at 32°C and least for those reared at 27°C temperature.

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