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INFLUENCE OF TEMPERATURE AND HUMIDITY LEVELS ON THE DEVELOPMENT OF KHAPRA BEETLE, *TROGODERMA GRANARIUM* EVERTS

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ABSTRACT

The growth and development of khapra beetle, *Trogoderma granarium* Everts was studied under stored conditions at different temperature (25°, 30°, 35° and 40°C) and humidity (60, 70, 80 and 90% R.H.) levels. The incubation period, larval and pupal period, pre-ovipositional and ovipositional period and longevity of adults (male and female) decreased with the increase in temperature, being shortest at 40°C. However, these parameters of growth and development increase with the decrease in humidity. The adult emergence, fecundity, egg viability and growth index was maximum at 35°C under 60 per cent relative humidity.

Key words: *Trogoderma granarium,* growth and development period, temperature, relative humidity

INTRODUCTION

Food grains are attacked by a number of insect pests under storage among which the khapra beetle, *Trogoderma granarium* Everts. is a major pest of stored grain. It is a serious pest of wheat only in larval stage. In order to develop economic and effective control measures for *T. granrium*, detailed and accurate knowledge of its bio-ecology is essential under variable macro and micro ecological conditions, which would help in the possible prediction of population levels and study of the various mortality factors regulating pest abundance. Hence, the present study was undertaken to determine the effect of physical factors on growth and development of *T. granarium.*

MATERIALS AND METHODS

Freshly laid eggs were obtained from adult reared at a temperature of 33±2°C and 60±5 per cent relative humidity. On hatching, newly hatched larvae were transferred to specimen tubes containing 10g wheat/moong. The experiment was conducted under laboratory conditions in the Department of Agricultural Entomology, S.K.N. College of Agriculture, Jobner from January 2005 to December 2007. Prior to the addition of larvae, the grains were sterilized and conditioned at least for a week in an incubator maintaining 33±2°C and 60±5 per cent relative humidity to raise their initial moisture content. The specimen tubes were covered with a piece of muslin cloth and kept under each combination of temperature and relative humidity. There were three replications in each case. The observations on incubation period, larval and pupal periods were recorded. The dates of adult emergence were taken to work out the pupal period. For total developmental period the average period for complete development was calculated taking the weighted means of the time required for egg, larval and pupal periods. The per cent emergence of adults was calculated by counting the adults in each treatment. The growth index was calculated by dividing percentage of adult emergence by total developmental period in days.

To study the fecundity, 5 pairs of freshly emerged beetles were released in glass vials (15 × 5 cm) for egg laying. The pre-oviposition and oviposition periods were recorded. The total numbers of eggs laid by the females were counted daily till the natural death of the females. For egg viability, 50 fresh eggs were placed in small specimen tubes (5 × 1 cm) and numbers of eggs hatched were recorded and percentage of hatchability was calculated. The longevity of male and female adults was determined by recording the dates of their emergence and the dates of their natural death.

RESULTS AND DISCUSSION

In the present investigation larval period, in general, has been inversely related to temperature *i.e.* the higher the temperature the shorter the larval period. The larvae complete their development in 16.60 days at 40°C and 60 per cent relative humidity, whereas, the maximum larval

period (58.10 days) was recorded at 25°C under 90 per cent relative humidity (Table-1). These findings are also in agreement with the results obtained by Jakhar *et al.* (2006) and Uniyal *et al.* (1972) for *Tribolium castaneum*, *Trogoderma granarium* and *Oryzaephilus* surrinamensis. Similarly, Saxena and Satyavir (1975) also stated that raising the temperature to 40°C reduced the length of different stages, while lowering the temperature to 28°C prolonged adult life and all the different periods.

The rate of pupal development was directly proportional to the temperature. The mean pupal period was shortest (3.94 days) at 40°C and longest (7.50 days) at 25°C. The data recorded on the combined effect of temperature and relative humidity revealed that shortest pupal period of 3.18 days was observed at 40°C and 70 per cent relative humidity (Table-2). The present findings corroborate with that of Satyavir (1980) on *T. granarium* who reported that pupal period was lower 40°C and 65 per cent relative humidity.

The maximum adult emergence (65.96%) was recorded when insect developed at 35°C. The results on interaction of temperature and relative humidity revealed that the combination of 35°C and 60 per cent relative humidity resulted in maximum (72.08%) adult emergence, whereas, it was minimum (37.00%) at 25°C under 90 per cent relative humidity (Table-3). These results confirm the findings of Singh *et al.* (1976) who reported that 35°C temperature and 60 per cent relative humidity were optimum for development of *T. granarium*.

The data on pre-ovipositional and ovipositional periods showed that the duration of these periods varied inversely with temperature and relative humidity. The shortest pre-ovipositional (1.50 days) and ovipositional (4.60 days) periods were observed at a combination of 40°C and 60 per cent relative humidity (Table 4&5). Similar trend of the duration of these periods, were previously reported by Saxena and Satyavir (1975) for *T. granarium*, supports the present observation.

Table 1: Influence of temperature and humidity levels and their interaction on larval period of *Trogoderma granarium* Everts

S. No.	Relative humidity (%)	Larval period (days)*				Mean
		Temperature (°C)				
		25	30	35	40	
1.	60	38.20	24.70	21.10	16.60	25.15
2.	70	44.90	27.50	18.90	17.30	27.15
3.	80	53.40	32.20	24.50	21.00	32.78
4.	90	58.10	36.00	29.70	24.80	37.15
	Mean	48.65	30.10	23.55	19.93	30.56
			SEm±	C.D. at 5%	C.V.%	
Temperature and relative humidity			0.42	1.21	4.76	
Temperature × relative humidity			0.84	2.42		

*Mean of 3 replications

Table 2: Influence of temperature and humidity levels and their interaction on pupal period of *Trogoderma granarium* Everts

S. No.	Relative humidity (%)	Pupal period (days)*				Mean
		Temperature (°C)				
		25	30	35	40	
1.	60	6.65	5.28	4.15	3.38	4.87
2.	70	7.27	6.05	4.37	3.18	5.22
3.	80	7.95	6.00	4.66	3.89	5.63
4.	90	8.13	6.46	5.70	5.30	6.40
	Mean	7.50	5.95	4.72	3.94	5.53
			SEm±	C.D. at 5%	C.V.%	
Temperature and relative humidity			0.08	0.23	4.93	
Temperature × relative humidity			0.16	0.45		

*Mean of 3 replications

Table 3: Influence of temperature and humidity levels and their interaction on adult emergence of *Trogoderma granarium* Everts

S. No.	Relative humidity (%)	Adult emergence (%)*				Mean
		Temperature (°C)				
		25	30	35	40	
1.	60	52.00 (46.15)	60.33 (50.96)	72.08 (58.10)	59.47 (50.46)	60.97 (51.42)
2.	70	48.53 (44.16)	52.73 (46.56)	68.00 (55.55)	45.66 (42.51)	53.73 (47.20)
3.	80	40.09 (39.28)	48.98 (44.24)	65.35 (53.94)	41.86 (40.32)	49.07 (44.45)
4.	90	37.00 (37.46)	42.55 (40.72)	58.40 (49.84)	35.00 (36.27)	43.24 (40.07)
	Mean	44.41 (41.76)	51.15 (45.62)	65.96 (54.36)	45.50 (42.39)	51.75 (46.03)
			SEm±	C.D. at 5%	C.V.%	
Temperature and relative humidity			0.78	2.26	5.91	
Temperature × relative humidity			1.57	4.52		

*Mean of 3 replications

Table 4: Influence of temperature and humidity levels and their interaction on pre-oviposition period of *Trogoderma granarium* Everts

S. No.	Relative humidity (%)	Larval period (days)*				Mean
		Temperature (°C)				
		25	30	35	40	
1.	60	3.50	2.95	1.87	1.50	2.46
2.	70	4.60	4.20	2.98	1.71	3.37
3.	80	5.10	4.00	3.96	3.10	4.04
4.	90	4.50	3.82	3.35	2.45	3.53
	Mean	4.43	3.74	3.04	2.19	3.35
			SEm±	C.D. at 5%	C.V.%	
Temperature and relative humidity			0.05	0.15	5.30	
Temperature × relative humidity			0.10	0.30		

*Mean of 3 replications

Table 5: Influence of temperature and humidity levels and their interaction on oviposition period of *Trogoderma granarium* Everts

S. No.	Relative humidity (%)	Oviposition period (days)*				Mean
		Temperature (°C)				
		25	30	35	40	
1.	60	7.00	5.10	5.00	4.60	5.43
2.	70	7.90	7.00	7.15	4.00	6.51
3.	80	8.35	8.20	7.95	6.10	7.65
4.	90	8.76	8.65	8.47	6.82	8.18
	Mean	8.00	7.24	7.14	5.38	6.94
			SEm±	C.D. at 5%	C.V.%	
Temperature and relative humidity			0.11	0.31	5.37	
Temperature × relative humidity			0.22	0.62		

*Mean of 3 replications

Maximum egg laying was observed at 35°C and minimum at 25°C. The maximum number of eggs laid per female (55.66/female) was observed in a combination of 35°C and 60 per cent relative humidity (Table-6). These findings get support from the observations of Lin (1971) and Sexena and Satyavir (1975) who reported that the maximum number of eggs are laid by female of *T. granarium* at 35°C and moderate at 40°C under 45 per cent relative humidity.

The results under present studies indicate that the maximum egg viability (82.00) was also observed at 35°C on the other hand, maximum hatching (69.16) was recorded at 60 per cent relative humidity (Table-7). A combination of 35°C and 60 per cent relative humidity was found to provide most favorable condition for egg viability (88.66). These findings are in confirmation with the work of Choudhary and Kapil (1978) on *T. granarium* who found the maximum hatching percentage (67.90%) at 35°C and 55 per cent relative humidity.

During present investigations the length of life of both sexes was inversely proportional with the temperature. The life of the male and female beetles were the longest at 25°C in combination with 90 per cent relative humidity (Table 8&9). The present studies confirm earlier observation of Saxena and Satyavir (1975) in *T. granarium,* Simwat and Chahal (1981) in *T. castaneum*, Nawrot (1981) in *C. cautella* and Faroni and Garcia-Mari (1992) and Chander (2003) in *R. dominica* who reported that the adult life-span decreased consistently with the rise in temperature.

The highest growth index (2.00) was at 35°C followed by 1.66, 1.18 and 0.74 at 40, 30 and 25°C temperature, respectively. At 60, 70, 80 and 90 per cent humidity, the growth index ranged from 0.68 to 1.28. Regarding the combined effect of temperature and relative humidity on the growth index, it was observed that at a combination of

Table 6: Influence of temperature and humidity levels and their interaction on fecundity of *Trogoderma granarium* Everts

S. No.	Relative humidity (%)	Fecundity (Eggs/female)*				Mean
		Temperature (°C)				
		25	30	35	40	
1.	60	42.66	52.00	55.66	50.66	50.25
2.	70	35.00	45.33	50.33	46.33	44.25
3.	80	30.33	41.33	45.00	30.66	36.83
4.	90	27.33	34.66	37.66	24.33	31.00
	Mean	33.83	43.33	47.16	38.00	40.58
			SEm±	C.D. at 5%	C.V.%	
Temperature and relative humidity			0.73	2.09	6.20	
Temperature × relative humidity			1.45	4.19		

*Mean of 3 replications

Table 7: Influence of temperature and humidity levels and their interaction on egg viability of *Trogoderma granarium* Everts

S. No.	Relative humidity (%)	Adult emergence (%)*				Mean
		Temperature (°C)				
		25	30	35	40	
1.	60	56.33 (48.64)	62.66 (52.33)	88.66 (70.32)	69.00 (56.17)	69.16 (56.87)
2.	70	51.00 (45.57)	58.33 (49.80)	92.00 (73.57)	64.33 (53.33)	66.42 (55.57)
3.	80	46.66 (43.08)	53.33 (46.91)	84.66 (66.99)	61.66 (51.74)	61.58 (52.18)
4.	90	40.33 (39.42)	47.66 (43.66)	62.66 (52.33)	38.66 (38.46)	47.33 (43.47)
	Mean	48.58 (44.18)	55.50 (48.18)	82.00 (65.80)	58.41 (49.93)	61.12 (52.02)
			SEm±	C.D. at 5%	C.V.%	
Temperature and relative humidity			0.94	2.71	6.28	
Temperature × relative humidity			1.88	5.43		

*Mean of 3 replications

Table 8: Influence of temperature and humidity levels and their interaction on longevity of male *Trogoderma granarium* Everts

S. No.	Relative humidity (%)	Longevity of male (days)*				Mean
		Temperature (°C)				
		25	30	35	40	
1.	60	9.25	8.65	8.10	7.80	8.45
2.	70	10.55	9.30	8.75	8.20	9.20
3.	80	13.50	11.70	11.00	8.60	11.20
4.	90	14.80	13.00	12.70	9.00	12.38
	Mean	12.03	10.66	10.14	8.40	10.31
			SEm±	C.D. at 5%	C.V.%	
Temperature and relative humidity			0.16	0.46	5.40	
Temperature × relative humidity			0.32	0.93		

*Mean of 3 replications

Table 9: Influence of temperature and humidity levels and their interaction on longevity of male *Trogoderma granarium* Everts

S. No.	Relative humidity (%)	Longevity of male (days)*				Mean
		Temperature (°C)				
		25	30	35	40	
1.	60	12.20	10.55	10.00	8.30	10.26
2.	70	15.80	13.20	12.70	10.40	13.03
3.	80	17.10	13.70	13.00	10.00	13.45
4.	90	17.25	14.00	13.20	12.20	14.16
	Mean	15.59	12.86	12.23	10.23	12.73
			SEm±	C.D. at 5%	C.V.%	
Temperature and relative humidity			0.20	0.58	5.48	
Temperature × relative humidity			0.40	1.16		

*Mean of 3 replications

Table 10: Influence of temperature and humidity levels and their interaction on growth index of *Trogoderma granarium* Everts

S. No.	Relative humidity (%)	Longevity of male (days)*				Mean
		Temperature (°C)				
		25	30	35	40	
1.	60	1.01	1.67	2.42	2.36	1.28
2.	70	0.81	1.30	2.34	1.82	1.11
3.	80	0.64	0.88	1.86	1.39	0.85
4.	90	0.54	0.85	1.38	0.98	0.68
	Mean	0.74	1.18	2.00	1.66	0.98

* Mean of 3 replications

35°C × 60 per cent relative humidity, the growth index was maximum (2.42). Singh *et al.* (1976) also found that growth index was highest for *T. granarium* at 35°C and 60 per cent relative humidity.

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