Plant Archives Vol. 20, Supplement 1, 2020 pp. 257-261 **e-ISSN:2581-6063 (online), ISSN:0972-5210**

EFFECT OF DIFFERENT LEVELS OF RELATIVE HUMIDITY AND IMPURITIES IN THREE STORED INSECTS

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Abstract

The study was conducted to estimate the effect of relative humidity levels (20, 30, 40, and 50%) and for all stages of insects *Trogoderma granarium, Tribolium castaneum and Tribolium confusum,* respectively, the results showed that the number of eggs laid by females was 23.3, 14.0 and 13.0, respectively and at a relative humidity of 50%, the *T. castaneum* and *T. confusum* were unable to lay eggs at humidity levels 20 and 30%, and the highest percentage of eggs hatching reached 43.3, 53.3, and 26.6%, respectively, at 50% relative humidity, and it also showed that the relative humidity 20 % Prevented a larvae to transformation pupa For the three insects , and the highest rate of larval transformation to pupa were 40.0, 30.0 and 26.6%, at relative humidity 50%, the percentage of (dust/grains) 50 g / kg gave the highest results in the number of laying eggs for each female reaching 71.0, 80.0 and 78.0, respectively, compared to the control treatment that reached 40.0, 83.0 and 81.0, respectively, and with eggs hatching rates. It reached 83.3, 76.6, 73.3% compared to the control treatment, it reached 89.9, 76.6, and 80.0%.

Keywords: humidity, impurities, insects

Introduction

Many biological factors such as weather conditions affect in plants and their products and Its impact on stored insects and the interaction between insects and plants and sometimes are very positive or negative reactions causing direct damage to plants or their products, the pests attack economically plants and their products in both pre- and post-harvest stages and are responsible for significant losses (Tounou *et al.,* 2014: Tariq *et al.,* 2015). Although the a wax layer on the external cuticle insects can easily lose moisture through the evaporation process, from the body of the insect. through respiration and defecation (1980 Busine & Hygiene), some insects can absorb moisture directly from the air, when the relative humidity reaches 45%, and most insects depend on the relationship between high relative humidity and high moisture content of the for stored food, eggs, and new larvae cannot survive as furniture beetles (*Anobium punctatum*) when the moisture content in wood is less than about 12%, which corresponds to the relative humidity of the balance is higher than 65%, and some insects, including insect of textile clothing, can stay in low-moisture areas by manufacturing water by metabolism of wool metabolism on which the larvae feed (Padfield & Borchersen, 2007), when the stored insects were exposed to varying degrees of humidity resulted in an increase in insect m0rtality rate with low relative humidity for example. *Tribolium castaneum, Tribolium confusum and Oryzaephilus surinamensis* (Woods, 2010), relative humidity affects the survival of insects by their ability to tolerate water changes in their body by the effect of moisture changes in their environment (Mark *et al*., 2013). High humidity increases the reproductive capacity of insects Where the proportion of water is related to the amount of fat in the eggs of female, and the evolution of the stages and its transformations through insect formation (Guarneri *et al.,* 2002), and to understand the nature reproductive of these pests, and dependence on many different climatic, and conditions responsible for natural reproduction, egg production, and hatching rates, relative humidity can affect the physiology, development, and duration of the incubation of eggs and the development of the egg-laying system of many insects positively or negatively (Garcia and Morrell 2009), low relative humidity Preventing embryo growth as well as in preventing hatching of eggs due to loss of the fatty layer and frailty cuticular of these insects (Brittany *et al*., 2015).

Relative humidity plays a major role in Presence any pest as well as increasing the toxic effect of pesticides, and it is useful in stopping the development of resistance in insects (Kay, 1976; Ebeling & Wagner, 1965). and ln a recent study to assess the effect of temperature (25,30 and 35 °C) and relative humidity (55, 60 and 65%) on fertility, egg hatching, cocoon formation and the appearance of adults, and appeared the a significant difference in the period of the development for different stages (Mansoor-ul-Hasan *et al*., 2017).

Repeated use of pesticides leads to biodiversity loss (Bengtsson *et al.,* 2005), and the use of insecticides on insects stored directly, such as the use of chemical gases or indirectly, as in empty stores (Malathion), But very specifically Because of the many conditions that do not harm the consumer, whether human or animal or the environment (Tooba & Tahir, 2005), for all of the reasons mentioned, the study targeted the environmental and climatic conditions that prevent the presence of insects in warehouses.

Material and Method

Breeding for insects

Trogoderma granarium, *Tribolium castaneum* and *Tribolium confusum* were obtained separately from a laboratory Store Insects, College of Agricultural Engineering Sciences, University of Baghdad to get two stages eggs and larvae for the three insects, by placing appropriate numbers of adults aged 2 days (males, females) at a ratio of 1: 1, and transfer to multiple dishes, the eggs and larva were transferred to, glass dishes Measuring (20 × 3) cm.

Effect of relative humidity dust on different stages of insects

The experiment was done through three duplicate and put 10 individuals each duplicate, for every treatment and stages of different insects, to study the effect of relative humidity 20, 30, 40, 50% in addition to the control treatment was left in laboratory conditions at a temperature of 35 °C and 65% RH, and study the ratios of dust (dust / grains) 0.025 and 0.050 (g/kg) separately and the results were compared with a control treatment of 0,000 (g / kg) at a temperature of 35 °C and 65% RH, to calculate the number of eggs laid by each female and the incubation period of eggs and ratios hatching and the number of larvae converted to the pupa and the duration of survival and ratios of pupa emerging to adults.

Relative Humidity Control:

The relative humidity was controlled by using a humidifier AUX Type KDY-DZOOL, Put inside a glass box measuring (1 × 0.75 × 1.5) m., relative humidity levels were read by Hygrometer Device

Statistical Analysis:

The Statistical Analysis System- SAS (2012) program was used to detect the effect of difference factors in study parameters. Least significant difference -LSD test was used to significant compare between means in this study.

Results

The results of Table-1 showed the effect of relative humidity (20, 30, 40, and 50)% respectively in the number of eggs laid / female, where a positive relationship between the number of eggs laid and the percentage of eggs hatching with high humidity, the results Separately, were 3.3, 16.0, 19.3, 23.3 compared to the control treatment that recorded 36.0 and 0.0, 26.6, 38.0, 43.3 compared to the control treatment that recorded 73.3 with high humidity and negative relationship with the egg incubation period, the statistical analysis indicated the significance of the results.

Table 1: Effect of Low Relative Humidity on Eggs of *T. granarium.*

Hatching %	incubation period	Egg laid /female	RH	Species
0.0	18.3	3.3	20	*T. granaruim*
26.6	14.6	16.0	30	
38.0	10.0	19.0	40	
43.3	9.0	23.3	50	
73.3	6.0	36.0	Control	
7.24 *	3.07 *	5.48 *	LSD value	

* (P≤0.05).

The results of Table-2 showed the effect of relative humidity (20, 30, 40, and 50)%, respectively, in a number the laid eggs/female, and the presence of a positive relationship between the number of eggs laid and the percentage of hatching eggs with high humidity, the results Separately for *T. castaneum* were 0.0, 0.0, 9.0, and 14.0 compared to the control treatment that recorded 67.0 and 0.0, 0.0, 44.6 and 53.3 compared to the control treatment that It recorded 76.6 and negative relationship with the egg incubation period, the statistical analysis indicated the significance of the results

Table 2 : Effect of Low Relative Humidity on Eggs of *T . castaneum.*

Hatching %	incubation period	Egg laid /female	RH	Species
0.0	0.0	0.0	20	*T. castaneum*
0.0	0.0	0.0	30	
44.6	18.0	9.0	40	
53.3	15.0	14.0	50	
76.6	13.0	67.0	Control	
7.62 *	3.42 *	6.59 *	LSD value	

* (P≤0.05)

The results of Table -3 showed the effect of relative humidity (40 and 50), respectively in number Egg laid / Female, where observed a positive relationship between the number of eggs laid with a high humidity, the results Separately for *T.confusum* were 3.0 and 13.0 compared to the control treatment recorded 42.0 and were unable to lay eggs at relative humidity 20, 30%, and the percentage of eggs hatching at relative humidity (20, 30, 40, and 50)%, respectively, was 0.0, 0.0, 0.0, 26.0 Compared to control treatment which recorded 73.3 and negative with egg incubation period, the statistical analysis indicated the significance of the results

Table 3: Effect of Low Relative Humidity on Eggs of *T. confusum.*

Hatching %	incubation period	Egg laid / female	RH	Species
0.0	0.0	0.0	20	*T. confusum*
0.0	0.0	0.0	30	
0.0	18.0	3.0	40	
26.6	17.0	13.0	50	
73.3	13.0	42.0	Control	
7.18 *	3.16 *	4.92 *	LSD value	

* (P≤0.05).

Table 4 showed the effect of relative humidity (20, 30, 40, and 50)% respectively, for *T. granarium* at the duration of the larval stage and the percentage of larvae converted to pupa and the duration of pupa, the results Separately, were 7.0, 58.0, 55.0, 6.6 compared to the control treatment recorded 46.0, and 0.0, 30.3, 33.3, 40.0 compared to the control treatment recorded 86.6 and 0.0, 8.9, 8.0, 7.33 compared to the control treatment recorded 6.0, the statistical analysis indicated the significance of the results.

Table 4 : Effect of different relative humidity on some stages of *T. granarium.*

Pupa period	Larvae transformed %	Larvae period	RH	Species
0.0	0.0	7.0	20	*T. granarium*
8.9	30.3	58.0	30	
8.0	33.3	55.0	40	
7.33	40.0	6.6	50	
6.0	86.6	46.0	Control	
2.58 *	8.53 *	6.71 *	LSD value	

* (P≤0.05).

Results of Table -5 showed the effect of relative (20, 30, 40, and 50)%, respectively, where observed a positive relationship between the larval period, the percentage of larvae transferred to pupa Separately for *T. castaneum* the results were 5.3, 18.0, 26.3, and 34.3 compared to the control treatment recorded 16. 6 and 0.0, 0.0, 24.4, 30.0 compared to that control treatment recorded 86.6 3 and negative with pupa period, the statistical analysis indicated the significance of the results.

Table 5 : Effect of different relative humidity on some stages of *T. castaneum.*

Pupa Period	Larvae transformed %	Larvae period	RH	Species
0.0	0.0	5.3	20	*T. castaneum*
0.0	0.0	18.0	30	
15.3	24.4	26.3	40	
9.6	30.0	34.3	50	
5.6	86.6	16.6	Control	
2.79 *	7.84 *	4.79 *	LSD value	

* (P≤0.05)

Results showed the table -6 -Effect of relative humidity (20, 30, 40, and 50) % respectively, where observed a positive relationship between larval Period, percentage of larvae transformed into pupae Separately, for *T. confusum* beetle, the results were 5.0, 17.6, 24.3, 33.6 compared to a control treatment that recorded 14.3 and 0.0, 0.0, 16.6, 26.6 compared to control treatment recorded 83.3 and negative with pupae Period, the statistical analysis indicated the significance of the results.

Table 6 : Effect of different relative humidity on *T. confusum.*

Pupa period	Larvae transformed %	Larvae period	RH	Species
0.0	0.0	5.0	20	*T. confusum*
0.0	0.0	17.6	30	
9.9	16.6	24.3	40	
9.0	26.6	33.6	50	
5.0	83.3	14.3	Control	
2.37 *	5.02 *	3.69 *	LSD value	

* (P≤0.05).

Results of table-7 showed the effect of dust ratios 25 and 50 g/kg, respectively, to *T. granarium* where observed a positive relationship between on the number of eggs laid and the percentage of hatching eggs Separately, the results were 53.0, 71.0 compared to the control treatment recorded 40.0 and the percentage of hatching eggs 63.3, 83.3 compared to the control treatment recorded 89.9 and negative with the incubation period ,the statistical analysis indicated the significance of the results, except for the incubation period of eggs.

Table 7 : Effect of dust/grains ratios on eggs *T. granarium.*

Hatching %	Incubation period	Egg laid / female	Dust / grain G / kg	Species
63.3	6.0	53.0	25	*T. granarium*
83.3	5.3	71.0	50	
89.9	5.3	40.0	Control	
6.28 *	0.854 NS	5.41 *	LSD value	

* (P≤0.05).

Results of Table- 8 showed the effect of dust ratios (Dust/grain) 25 and 50 g / kg respectively, in the number of eggs laid For a *T. castaneum*, the results were Separately 79.0, 82.0 compared to control treatment recorded 83.0 and incubation period 13.6, 11.0 compared to control treatment recorded 14.0 and the percentage of hatching eggs 59.9, 76.6 compared to control treatment recorded76.6. the statistical analysis indicated the significance of the results, except for the amount of eggs laid.

Table 8 : Effect of dust/grains ratios on eggs *T.castaneum.*

Hatching %	Incubation period	Egg laid/ female	Dust/grain G/kg	Species
59.9	13.6	79.0	25	*T. castaneum*
76.6	11.0	82.0	50	
76.6	14.0	83.0	Control	
6.53 *	2.59 *	4.82 NS	LSD value	

* (P≤0.05).

Results of Table 9 showed the effect of dust ratios(Dust/grain) 25 and 50 g / kg, respectively, Number of eggs laid for *T. confusum*, with the increase of dust percentage, the results were Separately, 66.0,78.0 compared to control treatment recorded 81.0 and incubation period of 14.3, 11.9 compared to control treatment recorded 15.3 and the percentage of hatching eggs 56.6, 73.3 compared to control treatment recorded 80.0. the statistical analysis indicated the significance of the results**.**

Table 9 : Effect of dust/grains ratios on eggs *T. confusum.*

Hatching %	incubation period	Egg laid/ female	Dust / grain G / kg	Species
56.6	14.3	66.0	25	*T. confusum.*
73.3	11.9	78.0	50	
80.0	15.3	81.0	Control	
5.77 *	2.61 *	5.68 *	LSD value	

* (P≤0.05).

Results of Table -10 showed the effect of dust ratios (Dust/grain) 25 and 50 g / kg, respectively, on larval duration, percentage of larvae transformed into pupa and pupae of *T. granarium.* Separately, the results were 49.0, 39.0, compared to the control treatment which recorded 43.0 and73.3, 80.0, compared to the control treatment which recorded 90.0 and 7.3, 5.6, compared to the control treatment which recorded 6.0, the statistical analysis indicated the significance of the results.

Table 10 : Effect of dust/grains ratios on some stages for *T. granarium.*

Pupa Period	Larvae transformed %	Larvae period	Dust / grain (G / kg)	Species
7.3	73.3	49.0	25	*T. granarium*
5.6	80.0	39.0	50	
6.0	90.0	43.0	Control	
1.51 *	6.37 *	5.02 *	LSD value	

* (P≤0.05).

Results of Table 11- showed the effect of dust ratios (Dust/grain) of 25 and 50 g / kg, respectively. In the duration of the larval stage, percentage of larvae transformed into pupa and duration of pupal stage of *T. castaneum* Separately, the results were 11.6, 12.0, compared to the control treatment recorded 12.6, and 60.0, 76.6 compared to the control treatment recorded 80.0 and 12.0, 11.0 compared to the control treatment recorded 11.6. the statistical analysis indicated the significance of the results**,** except for the Larvae period and Pupa Period .

Table 11 : Effect of dust/grains ratios on some stages for *T. castaneum*.

Pupa Period	Larvae transformed%	Larvae period	Dust/grain (G/kg)	Species
12.0	60.0	11.6	25	*T. castaneum*
11.0	76.6	12.0	50	
11.6	80.0	12.6	Control	
1.09 NS	6.55 *	1.38 NS	LSD value	

* (P≤0.05).

Results of Table -12 showed the effect of dust ratios (Dust/grain) 25 and 50 g / kg, respectively, on larval duration, percentage of larvae transformed into pupa and pupae of *T. confusum*. Separately, the results were 12.3, 13.0, compared to the control treatment4 which recorded 12.0 and 56.6, 66.6, compared to the control treatment which recorded 86.6 and 8.9, 6.3, compared to the control treatment which recorded 10.3, the statistical analysis indicated the significance of the results, except for the Larvae period.

Table 12 : Effect of dust/grains ratios on some stages for *T. confusum*.

Pupa Period	Larvae transformed%	Larvae period	Dust / grain G / kg	Species
8.9	56.6	12.3	25	*T. confusum*
6.3	66.6	13.0	50	
10.3	86.6	12.0	Control	
2.67 *	6.41 *	1.07 NS	LSD value	

* (P≤0.05).

Discussion

High relative humidity contributes to increasing the number of stored insects, the effect of high humidity on *Callosobruchus maculatus* and in laboratory conditions (Ouedraogoa *et al.,* 1996) and the effect of relative humidity on the ability to hatch eggs of *D. minutus* and showed up a high mortality rate at 20% and 85% relative humidity levels compared to between 40% and 75%, and recorded lowest percentage hatching of eggs at the relative humidity levels of 20% and 85%, and the egg is exposed to loss of moisture which leads to prevent hatching of eggs to larvae, and high relative humidity resulted in inhibition of egg hatching and low reproductive capacity and incubation period For *D. minutes*, the average number of eggs laid increased from 3.20 ± 0.31 to 56.50 ± 1.21 with increased relative humidity from 20% to 85% and female beetles prefer to lay eggs in high relative humidity, the number of eggs also increases with increasing relative humidity and decreasing the period before laying eggs with increasing relative humidity. adult females showed higher fertility characteristics with increased relative humidity, and increase movement will also increase water loss by spiracles due to increased breathing (Zachanassen, 1991). (Emad *et al.*, 2004) indicated when they studying the insect flyworm has the effect of humidity on the stages of the insect, and the relative humidity 20,40% leads to dehydration and lack of hatching, and the relative humidity above 60% is the best for hatching eggs and causes an increase in the duration of the larval stage, *Sitophilus oryzea* L. is the primary and internal feeder of maize, wheat, barley particularly of rice .The current study was conducted to evaluate the effect of temperature (25, 30 and 35 °C) and relative humidity (55, 60 and 65%) on the fecundity, egg hatching, pupae formation and adult emergence and it showed the significantly difference regarding to the time period for different developmental stages.

Soil moisture can affect the time of egg hatching through a direct impact on eggs or by modifying the spawning behavior of fertilized females. Mole cricket eggs absorb water as they grow and increase their size by 25% before hatching (Jacques *et al.*, 1981). In a study (James, 2017), it aims to determine whether female fertilized insects can be affected by soil and the salts it contains affect the laying of eggs, egg development, survival, egg hatching ratios, body weight and survival, It was noted that the water balance occurred between the egg and the impurities in about 12 parts per million of sodium chloride associated with the aqueous activity and that its increase from this limit caused a reduction in the size of the eggs.

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