The effect of low and highly temperature degree on red rust flour beetle Tribolium castaneum. (Tenebrionidae : Coleoptera)

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Abstract

The study was carried out in the life sciences laboratory of Education College of Hawija for the purpose of studying the effect of low and high temperatures on rust red flour beetle Tribolium castaneum (Coleoptera: Tenebrionidae). The results of the study showed that the lower thermal temperatures 0.0, -4, -5.0, -10.0 and 10.15°C caused the killing in the different phases of the red rust beetle in high proportions, while the moderately temperatures 10.0, 15, 20, 25, and 35°C don't killed any individual insect because most of these temperatures are in fact suitable for the life activity and effectiveness of the insect but highly temperatures like, 50, 55, 60, 65, 70, were caused highly mortality for red rust flour beetle that reached to 100% for all developmental stages (larva, pupa, and adult) during most exposure times.

Keywords: Tribolium castaneum, Low temperature, Highly temperature.

1. Introduction

Cereals subject to different insect pests in stores like Tribolium castaneum One of the most important types of flour beetles attacked cereals and their products wheat [1] Elasticity So the infested flour loss their Viscosity Flour beetles also known since ancient times as insect pests are found with foodstuffs stored as flour or grain and bran preserved in vessels and pottery vessels in the ancient Egyptians were observed in the tombs of the Pharaohs in 2500 BC. Its present existence is the same for more than four thousand years [2,3]. Salman [4] indicated that the Tribolium castaneum caused by store insects is color change, weight loss, contamination of chemical residues, secretions and transfer of pathogens. One of the most dominant methods control of store insects use of fumigant gases such as methyl bromide, hydrogen phosphide and others[5]. But the use of this method at present is undesirable for known reasons, including the emergence of strains resistant to the act of evaporators after a period of exposure or because of the remains of food or to involve the risks to the environment and the lives of workers in control [5]. Therefore, specialists in the fight against insect stores to find alternatives to this method, including, physical methods such as, Diatomaceous earth (DE) [6] against Tribolium castaneum, sterilization gamma rays. As well as the use of high or low temperature where found at (50 °C) can fight red beetles [7]. The use of air stages when exposed for an hour or two [8] combating beetles In latest years, researchers have resort to safe alternatives to insect control of stored materials [9] and after 3 - 9 days graduated adults, and take their life cycle from laying eggs until the exit of the insect about 4-10 weeks depending on temperature, relative humidity, effect quality and quantity of food [5]. We can use some physical methods against stored product insects [10]. The highly temperature degrees were studied against Ephesia cautella in Iraq [11] and [5] Studied the effect of high temperature on Trogoderma granarium . [12] Studied physical experiments using non-ionised radiation from amicrowave oven with 2450 Mhz at three power levels and exposure times when set at 200 W for 30s , the killing rate of larvae, pupae, and adult were 43.33, 53.33, and 40.00% respectively . Fields [13] Indicated it is possible to use high temperature against stored product insects and mites. [14] Studied A thermal lethal model of rice weevil subjected to microwave irradiation. Khuedier [15] Studied the effect of elevated temperature degree 30,35,40,45,50,55°C on larval stage of Trogoderma granarium so this researcher also studied the effect of solar heating on adult stage of this pest . Qader[16] studied the effect of elevated temperature( 40,45,50,55,60°C) on Khapra beetle Trogoderma granarium during 14 exposure times and he concluded that the mortality increased when both temperature degree and exposure time increased. Salem Abo-Mulla [4] Studied the effect of high and low temperature degree on the growth and remain of Khapra beetle (Trogoderma granarium Everts results also showed that exposure to 45°C for 6 hours was lethal for all insect stages,While temperature 3-4 temp are unsuitable to insect .
Philip Burrell 2016 researcher has shown that the successful cooling technology for stored grains and through which we keep the grain temperature under 15°C inside the grain silo provides many benefits, including reducing the population of insect pests present in stored grains. The use of the cooling technology contributes to providing good grains that give a high germination rate when planted in the fields. Grain cooling technology also helps reduce the growth and development of molded fungi, thereby improving the quality [16]. Studied the effect of different lower temperature on Tribolium castaneum and they concluded this species very sensitive or susceptible to chilling and highest mortality happened at (-22) degree, also they studied the effect of cold acclimation on the level of Trehalose, Sorbitol, and myo-inositol. [2] That all flour beetles, Tribolium castaneum (Herbst), stages are sensitive to the effect of elevated temperature between 40-60°C so this author said that 120 min are required to kill 95% of exposed T. castaneum Arestyl useful to decrease insect pest population in grain store was investigated by [12] and [18], [19], studied the elevated temperature degree in flour beetle, Tribolium castaneum 2. Material and Methods

Large numbers of rust flour beetles were obtained from infected flour from the flour stores from the city of Kirkuk and then brought to a biological laboratory in the life sciences department of the College of Hawija Education and was bred inside an incubator at a temperature of 30°C and a relative humidity of 70% where this insect was raised on regular wheat flour. Added to it 5% [20,21] regular baking yeast where adult insects, male and female, were added inside 800 ml glass bottles with each of the flour added to him baking yeast, knowing that the added amount for each bottle is 100 g of food (flour + yeast) after that. Covering the culture bottles with cloth pieces from their nozzles, and then tied with a red MeR rubber and then transferred to the inside of the incubator. We get the insects necessary to carry out the required experiments in this study were colonies of insect inside the bottles will be constantly updated by the effect of low temperature and elevated temperature conducted on three developmental stages of Tribolium castaneum like larva, pupa, and adult stage. By putting 10 individuals of each stage inside every petri dish from (9 mm) diameter so every treatment, replicated three times. The effect of low temperatures conducted inside refrigerator but highly temperature conducted inside incubator (Memmert, made in Germany). All the petri dishes that containing the insect developmental three stages (larva, pupa, and adult) were putting inside both refrigerator and incubator and after finished the experiment the mortality of each treatment with every exposure times were recorded and the data were collected and subjected to statistical analysis. Experimental Design and Statistical Analysis: RCBD. The experiment was designed according to the RCBD Design. Each treatment is repeated four times, including the comparison treatment.

The results were statistically analyzed and the mean coefficients were compared according to the Dunkin polynomial test and the likelihood of a 5% probability.

3. Results and Discussion

The results of table 1 showed that the mortality percentage were (0.0%) at (35,30,25,20,15, and 10) temperature degree during all exposure times (5, 10, 15, 20, 25, 30, 35, 40, 45, 50, 55, 60, and 65 minutes). Mortality was 0.0% during (5 minutes) for -5.0 but was 100% during (55, 60, 65 minutes) for the same temp. degree. The results also indicated mortality was lowest 0.0% during 5 minute but the highest was 100% during 50, 55, 60, and 65 minutes for (-10) temp. degree. The mortality also were (0.0%) during all exposure times for -12, -15 temperature degree. We concluded that the mortality increase gradually according to any decrease happened in temperature and to any ssincrease in exposure time. These results accept with [22,23].

Table 1. The effect of different temperature degree on larval stage of Tribolium castaneum

| Temperature (°C) | Exposure Time (Minutes) |
|-----------------|-------------------------|
| 35              | 5  | 10 | 15 | 20 | 25 | 30 | 35 | 40 | 45 | 50 | 55 | 60 | 65 |
| 30              | 0.0a | 0.0a | 0.0a | 0.0a | 0.0a | 0.0a | 0.0a | 0.0a | 0.0a | 0.0a | 0.0a | 0.0a |
| 25              | 0.0a | 0.0a | 0.0a | 0.0a | 0.0a | 0.0a | 0.0a | 0.0a | 0.0a | 0.0a | 0.0a | 0.0a | 0.0a |
Figures with similar letters mean that there are no significant differences between the averages of the transactions according to the Dunkin multi-range test at the probability 5% level.

The results of table 2, showed that the mortality percentage were (0.0%) at (35,30,25,20,15, and 10) temperature degree during all exposure times (5,10,15,20,25,30,35,40,45,50,55,60,and65 minutes). Also the results showed that mortality was 5% during 5 minutes but was 100% during 65 minutes for 0.0 temperature degree. Mortality was 10% during 5 minutes but was 100% for -5 temperature degree. Mortality was 15% during 5 minutes but was 100% for -12 temperature degree. So the results showed mortality was 32% during 5 minutes but was 100% for -15 temperature degree. These results are consistent with [22,23].

**Table 2.** The effect of different temperature degree on Pupal stage of Tribolium castaneum

| Temp Degree | Mortality (%) |
|-------------|---------------|
| Exposure Time (Minutes) | 5 | 10 | 15 | 20 | 25 | 30 | 35 | 40 | 45 | 50 | 55 | 60 | 65 |
| 35 | 0.0a | 0.0a | 0.0a | 0.0a | 0.0a | 0.0a | 0.0a | 0.0a | 0.0a | 0.0a | 0.0a | 0.0a | 0.0a |
| 30 | 0.0a | 0.0a | 0.0a | 0.0a | 0.0a | 0.0a | 0.0a | 0.0a | 0.0a | 0.0a | 0.0a | 0.0a | 0.0a |
| 25 | 0.0a | 0.0a | 0.0a | 0.0a | 0.0a | 0.0a | 0.0a | 0.0a | 0.0a | 0.0a | 0.0a | 0.0a | 0.0a |
| 20 | 0.0a | 0.0a | 0.0a | 0.0a | 0.0a | 0.0a | 0.0a | 0.0a | 0.0a | 0.0a | 0.0a | 0.0a | 0.0a |
| 15 | 0.0a | 0.0a | 0.0a | 0.0a | 0.0a | 0.0a | 0.0a | 0.0a | 0.0a | 0.0a | 0.0a | 0.0a | 0.0a |
| 10 | 0.0a | 0.0a | 0.0a | 0.0a | 0.0a | 0.0a | 0.0a | 0.0a | 0.0a | 0.0a | 0.0a | 0.0a | 0.0a |
| 0.0 | 5a | 12b | 20b | 25b | 28 | 30 | 40 | 45 | 60 | 75 | 91b | 96b | 100b |
| -5 | 10a | 20c | 22b | 27b | 33a | 46b | 52c | 55c | 66c | 91 | 100c | 100b | 100b |
| -10 | 15a | 23c | 25c | 40c | 50b | 55b | 64d | 71 | 96d | 100 | 100b | 100b | 100b |

The mortality percentage were (0.0%) at (35,30,25,20,15, and 10) temperature degree during all exposure times (5,10,15,20,25,30,35,40,45,50,55,60,and65 minutes). Also the results showed that mortality was 5% during 5 minutes but was 100% during 65 minutes for 0.0 temperature degree. Mortality was 10% during 5 minutes but was 100% for -5 temperature degree. Mortality was 15% during 5 minutes but was 100% for -12 temperature degree. So the results showed mortality was 32% during 5 minutes but was 100% for -15 temperature degree. Any increase in exposure time. These results are consistent with [22,23].
The results of table 3. showed that the mortality percentage were (0.0%) at (35, 30, 25, 20, 15, and 10) temperature degree during all exposure times (5, 10, 15, 20, 25, 30, 35, 40, 45, 50, 55, 60, and 65 minutes). The results indicated that mortality was 0.0% during 5 minutes but was 100% during 60 and 65 minutes for 0.0 temperature degree. But the results also showed mortality was 25% during 5 minutes and the highest mortality 100% recorded during 55, 60, and 65 minutes for -5 temperature degree. The results pointed to the lowest mortality 40% recorded during 5 minutes but the highest 100% recorded during 50, 55, 60, and 65 minutes for -10 temperature degree. The results also indicated that the lowest mortality 50% recorded during 5 minutes but the highest was 100% recorded during 45, 50, 55, 60, and 65 minutes for -12 temperature degree. The results also showed that lowest mortality 60% was recorded during 5 minutes but the highest mortality 100% recorded during 40, 45, 50, 55, 60, and 65 minutes for -15 temperature degree. These results accepted with any increase in exposure time. These results accept with [22-24].

Table 3. The effect of different temperature degree on pupal stage of Tribolium castaneum

| Temp Degree | Exposure Time (Minutes) | Mortality (%) |
|-------------|-------------------------|---------------|
|             | 5          | 10          | 15          | 20          | 25          | 30          | 35          | 40          | 45          | 50          | 55          | 60          | 65          |
| 35          | 0.0a       | 0.0a       | 0.0a       | 0.0a       | 0.0a       | 0.0a       | 0.0a       | 0.0a       | 0.0a       | 0.0a       | 0.0a       | 0.0a       | 0.0a       |
| 30          | 0.0a       | 0.0a       | 0.0a       | 0.0a       | 0.0a       | 0.0a       | 0.0a       | 0.0a       | 0.0a       | 0.0a       | 0.0a       | 0.0a       | 0.0a       |
| 25          | 0.0a       | 0.0a       | 0.0a       | 0.0a       | 0.0a       | 0.0a       | 0.0a       | 0.0a       | 0.0a       | 0.0a       | 0.0a       | 0.0a       | 0.0a       |
| 20          | 0.0a       | 0.0a       | 0.0a       | 0.0a       | 0.0a       | 0.0a       | 0.0a       | 0.0a       | 0.0a       | 0.0a       | 0.0a       | 0.0a       | 0.0a       |
| 15          | 0.0a       | 0.0a       | 0.0a       | 0.0a       | 0.0a       | 0.0a       | 0.0a       | 0.0a       | 0.0a       | 0.0a       | 0.0a       | 0.0a       | 0.0a       |
| 10          | 0.0a       | 0.0a       | 0.0a       | 0.0a       | 0.0a       | 0.0a       | 0.0a       | 0.0a       | 0.0a       | 0.0a       | 0.0a       | 0.0a       | 0.0a       |
| 0.0         | 0.0a       | 12b        | 15b        | 35b        | 45b        | 56b        | 67b        | 72b        | 77b        | 86b        | 93b        | 100        | 100        |
| -5          | 25b        | 33c        | 40c        | 57c        | 60c        | 66c        | 72b        | 78b        | 87c        | 91b        | 100        | 100        | 100        |
| -10         | 30b        | 45d        | 50d        | 61c        | 65c        | 68c        | 76b        | 82b        | 96         | 100        | 100        | 100        | 100        |
| -12         | 38c        | 50d        | 50d        | 65c        | 69c        | 70c        | 100        | 100        | 100        | 100        | 100        | 100        | 100        |
| -15         | 40c        | 55d        | 65e        | 68c        | 73c        | 100        | 100        | 100        | 100        | 100        | 100        | 100        | 100        |

Figures with similar letters mean that there are no significant differences between the averages of the transactions according to the Dunkin multi-range test and at the probability 5% level.
The results of table 4, indicated that mortality percentage were (0.0%) at (25, 30, 35, 40, 45,) temperature degrees during all exposure times (5, 10, 15, 20, 25, 30, 35, 40, 45, 50, 55, 60) minutes. The results of table 4, showed lowest mortality 10% recorded during 5 minutes but the highest mortality 100% recorded during 60 and 65 minutes. Also results indicated lowest mortality 20% recorded during 5 minutes but the highest 100% was recorded during 55, 60 and 65 minutes. So the results also showed that lowest mortality 35% was recorded during 5 minutes but the highest 100% recorded during 45, 50, 55, 60, and 65 minutes. These results accepted with Mahroof et al. 2001 who indicated that all flour beetle, Tribolium castaneum (Herbst) stages are sensitive to the effect of elevated temperature between 40-60°C so this author said that 120 min are required to kill 95% of exposed T. castaneum life stages at >50°C. These results accepted with [26].

**Table 4.** The effect of highly temperature degree on larval stage of Tribolium castaneum.

| Temp Degree | Exposure Time (Minutes) |
|-------------|-------------------------|
| 25          | 0.0a 0.0a 0.0a 0.0a 0.0a 0.0a 0.0a 0.0a 0.0a 0.0a 0.0a 0.0a |
| 30          | 0.0a 0.0a 0.0a 0.0a 0.0a 0.0a 0.0a 0.0a 0.0a 0.0a 0.0a 0.0a |
| 35          | 0.0a 0.0a 0.0a 0.0a 0.0a 0.0a 0.0a 0.0a 0.0a 0.0a 0.0a 0.0a |
| 40          | 0.0a 0.0a 0.0a 0.0a 0.0a 0.0a 0.0a 0.0a 0.0a 0.0a 0.0a 0.0a |
| 45          | 0.0a 0.0a 0.0a 0.0a 0.0a 0.0a 0.0a 0.0a 0.0a 0.0a 0.0a 0.0a |
| 50          | 10b 15b 20b 25b 50b 75b 95b 99b 100b 100b 100b 100b |
| 55          | 20c 25c 30c 40c 60c 80c 97b 100c 100b 100b 100b 100b |
| 60          | 35d 60d 75d 75d 100d 100d 100c 100c 100b 100b 100b 100b |

Figures with similar letters mean that there are no significant differences between the averages of the transactions according to the Dunkin multi-range test and at the probability 5% level.

The results of table 5, indicated that mortality percentage were (0.0%) at (25, 30, 35, 40, 45,) temperature degrees during all exposure times (5, 10, 15, 20, 25, 30, 35, 40, 45, 50, 55, 60) minutes. The results showed lowest mortality 10% recorded during 5 minutes but the highest mortality 100% recorded during 60 and 65 minutes. Also results indicated lowest mortality 20% recorded during 5 minutes but the highest 100% was recorded during 55, 60 and 65 minutes. So the results also showed that lowest mortality 35% was recorded during 5 minutes but the highest 100% recorded during 45, 50, 55, 60, and 65 minutes. These results accepted with [26].

**Table 5.** The effect of highly temperature degree on pupal stage of Tribolium castaneum.

| Temp Degree | Exposure Time (Minutes) |
|-------------|-------------------------|
| 25          | 0.0a 0.0a 0.0a 0.0a 0.0a 0.0a 0.0a 0.0a 0.0a 0.0a 0.0a 0.0a |
The results of Table 6 indicated that mortality percentage were (0.0%) at (25, 30, 35, 40, 45, 50, 55, 60) temperature degrees during all exposure times (5, 10, 15, 20, 25, 30, 35, 40, 45, 50, 55, 60) minutes. The results showed lowest mortality 25% recorded during 5 minutes but the highest mortality 100% recorded during 45, 50, 55, 60, and 65 minutes for 60 temperature degree. Also results indicated lowest mortality 35% recorded during 5 minutes but the highest 100% was recorded during 40, 45, 50, 55, 60 and 65 minutes. So the results also showed that lowest mortality 45% was recorded during 5 minutes but the highest 100% recorded during 35, 40, 45, 50, 55, 60, and 65 minutes for 60 temperature degree. These results accepted with [26, 12].

**Table 6.** The effect of highly temperature degree on adult stage of Tribolium castaneum

| Temp | Exposure Time (Minutes) |
|------|-------------------------|
| 5    | 10 | 15 | 20 | 25 | 30 | 35 | 40 | 45 | 50 | 55 | 60 | 65 |
| 25   | 0.0a | 0.0a | 0.0a | 0.0a | 0.0a | 0.0a | 0.0a | 0.0a | 0.0a | 0.0a | 0.0a | 0.0a | 0.0a |
| 30   | 0.0a | 0.0a | 0.0a | 0.0a | 0.0a | 0.0a | 0.0a | 0.0a | 0.0a | 0.0a | 0.0a | 0.0a | 0.0a |
| 35   | 0.0a | 0.0a | 0.0a | 0.0a | 0.0a | 0.0a | 0.0a | 0.0a | 0.0a | 0.0a | 0.0a | 0.0a | 0.0a |
| 40   | 0.0a | 0.0a | 0.0a | 0.0a | 0.0a | 0.0a | 0.0a | 0.0a | 0.0a | 0.0a | 0.0a | 0.0a | 0.0a |
| 45   | 0.0a | 0.0a | 0.0a | 0.0a | 0.0a | 0.0a | 0.0a | 0.0a | 0.0a | 0.0a | 0.0a | 0.0a | 0.0a |
| 50   | 25b | 45b | 60b | 75b | 95b | 100 | b | b | b | b | b | b | b |
| 55   | 35c | 55c | 65b | 85c | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | b |
| 60   | 40c | 7d | 95c | 100d | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | b |

Figures with similar letters mean that there are no significant differences between the averages of the transactions according to the Dunkin multi-range test and at the probability 5% level.
Conclusions

It was found that the temperature 0.0, -4.0, -5.0, and -10.0, -12, -15 are appropriate and appropriate temperatures in controlling the red rust beetle, as it became clear from the results of this study that the longer the period of exposure of insects to low temperatures resulted in an increase in the killing rate. The study also showed that the 25, 30 and 35 °C temperatures are not useful in controlling the insect because they are temperatures that activate the vital activities of the insect and all its activities.

So the results also indicated that the elevated temperatures like 50, 55, 60, 65 temp. degree are very good to kill all beetle stages so the mortality reached 100% during most exposure time.

Recommendation

Elevated and low temperature to control insect pests of warehouse, like, Tribolium confusum, Callosobruchus maculatus, Trogoderma granarium, Bruchus pisorum, Bruchus pisorum, Callosobrachus chinensis is very safety method so we advise and recommend to investigate about the effect of highly and low temperature against these mentioned insect species in future because these pests are big problems on cereals and stored grains and their products.

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