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POPULATION DYNAMICS OF *TRIBOLIUM CASTANEUM* (HERBST) IN DIFFERENT ABIOTIC CONDITIONS ON STORED FIG *FICUS CARICA*

Shah Zaib Fazal[1*], Farooq Ahemd[2], Imran Ali Sani[3], Salman Aziz[5],M. Sagheer[2], Shahzaman[2], Matiullah jaffar[2], Faheem Shahzad[1], Azmatullah shah[1], Maryam Arif[4], Shahjahan shabbir[3], Nisar Ahmed[3],Umair Ahmed[3], Muhammad Murad[3]

[1] Agriculture Research Institute, Quetta, Pakistan.
[2] University of Agriculture Faisalabad, Pakistan.
[3] Balochistan University of Information Technology, Engineering and Management Sciences, BUITEMS Quetta, Pakistan.
[4]University Of Balochistan, Quetta, Pakistan
[5]Balochistan Agriculture College Quetta Pakistan

Abstract:

Stored products infestation by insect pests is a serious issue all over the world as this causes severe threat to the quantity and quality of food commodities. Insect pests attack to stored grains may cause significant weight loss, reduced seed variability and nutritional losses. A variety of insect pests are injurious to stored grains and their infestation is enhanced by poor storage conditions and environmental factors particularly temperature and relative humidity. Current experiment was conducted to check the effect of modified abiotic conditions on the mortality and infestation rate of two most destructive insect pests of stored products i.e Tribolium castaneum (Herbst) and Oryzaephilus.surinamensis. Three levels of temperatures (20, 30 and 40^{0}C) with 50 and 70% relative humidity were used during experimentation. Different abiotic conditions were ensured using incubator (SANYO incubator, MIR-254). The test insect species were exposed for 30 and 60 days to different combinations of temperatures and relative humidity. The experiment was performed on sterilized fig and Completely Randomized Design (CRD) with three replicates for each treatment was used. The observed data was subjected to Analysis of Variance using statistix 8.1software at 5% level of significance. The results of the study showed that maximum mean mortality (55.00%) after exposure period of 30 days and (65.00%) after exposure period of 60 was found for Tribolium castaneum at 50% relative humidity with 40^{0}C whereas for Oryzaephilus.surinamensis maximum mean mortality (56.66%) and (73.33%) was obtained after exposure period of 30 and 60 days respectively. Data regarding infestation showed that maximum mean infestation rate for Tribolium castaneum was (87.50%) at 70% R.H with 30^{0}C and minimum infestation rate (45.83%) was noticed at 50% with 40^{0}C while for Oryzaephilus.surinamensis maximum and minimum infestation rate with mean value of (89.16%) and (55.83%) were observed at 70% R.H with 30^{0}C and 50% R.H with 40^{0}C respectively. The results of the study demonstrated that modified abiotic conditions can be successfully used in integrated pest management programs as an alternative to synthetic chemicals in stored products protection against insect pests.

Corresponding Author:

Shah Zaib Fazal,
Agriculture Research Institute,
Quetta, Pakistan.
fazalshahzaib@gmail.com

QR code

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INTRODUCTION:

Stored products infestation by insect pests is a serious issue all over the world as this causes severe threat to the quantity and quality of attacked food commodities. Insect pests attack to stored grains may cause significant weight loss, reduced seed variability and nutritional losses [1]. A variety of insect pests are injurious to stored grains and their infestation is enhanced by poor storage conditions and environmental factors particularly temperature and relative humidity [2].

The saw toothed beetle, *Oryzaephilus.surinamensis* (L.), is a cosmopolitan and common insect pest of stored grains [3]. It refer as a secondary pest of stored products because it cannot damage intact grain; nevertheless, its status has altered due to mechanical injury of grains during drying and harvesting, which outcomes in damaged and broken grains going to storage amenities, where this pest will grow and responsible for high infestation complications ([4].

Red flour. Beetle, Tribolium castaneum.is an important and cosmopolitan pest in tropical and subtropical parts of the world [5]. Both, adults and larvae feed on extensive variety of dry vegetative materials, such as milled cereal products, wheat flour, milled rice and peanuts causing severe losses in both the quantity and quality of the stored products [6,7]. An emergent need of the time is to develop control strategies against these destructive pests. Insect pests controlling history of past seven decades has been written primarily by toxicologists and chemists, after the astonishing success of synthetic insecticides in 1950's [8].

Outcomes of which introduced the hazardous impacts on almost all life forms and environment. It includes the problems like resistant pest populations, pesticide residues and insecticides' deregulation [9]. Evidences have been provided by investigations that the use of synthetic insecticides in stored grains put hazardous impacts on mammals and non-target organisms. In context of stored grains, research shows that pests like R. dominica, T. castaneum and some others have developed resistance against various insecticides of synthetic origin [10,11].

These harmful effects of synthetic insecticides have, therefore, emphasized to find out non-chemical pathways for pest management [12]. Infestation of grains by insects due to biotic factors pests are cause losses of stored products every season worldwide [13]. Abiotic factors technology considered seriously for the stored grain quality [14]. various storage locations are different in their physical properties, climate, space-time dynamics within the storage period. reduce the attack of various pest use the separated effects of abiotic factors on pest populations, i.e. climate [14], humidity and temperature [15]. In South-East Asia damage of stored food is serious problem due to poor facilities. during storage protection from pests seal holes and cracks with muddy structure and some other traditional material are used its reduce the insects activity.

Temperature and humidity in grain repository may be altered to harm fully in flounce the growth rate of insect pests [16-19] by effecting on fecundity, survivor ship and development rate. As like population progress rate, development rate rises from in fervor threshold up to the optimal temperature and then drops quickly [20,21]. At low-temperature, population growth-rate is generally more-sensitive to changes-in development rate-than it is toinfluences of fecundity-and survivorship [22,23]. On the other-hand, at optimum-temperatures about 330C-grain moisture content-has a much-greater effect upon population-growth rate. This-is largely due-to its effect upon-fecundity rather than-on development rate- [24-26]. The chemical insecticides are use for control the insect pest such as fumigants are extensively use in stored grain facilities its kill all life stages of stored product pests [27], contact insecticides are sprayed directly on grain or structure it gives protection from insect infestation for some months [28] there are many reasons people looking alternatives because of widespread resistance in insect populations [29] there is some alternatives that is high temperature are use in china for disinfest grain [30] heat continues used for controlling insect pest in stored grain facilities. At 40-45oC stored grain pests die within 24 hours [31-37].

The fig (Ficus carica) of family Moraceae usually present in Mediterranean, western Asian. Iran is fourth ranke in the world for dried fig production [38]. Figs have rich amount of fiber, vitamins and minerals. Figs are grown in humid and semi humid areas. It does not contain cholesterol, fat and they have large quantity of anthocyanins, flavonoids, polyphenols, amino acids. Which are necessary for human health [39,40]. According to Quran fruits like fig, date, olive heavenly fruits or gift from Allah. Fresh or dry fruits not only good food its also use as medicine [41]. Hazrat Abu Darda (Radiallaho Anho) narrates that someone presented the Prophet a plate of figs and he said, "Eat figs! If I would say a certain type of fruit was sent down to us from the heavens I would say it's a fig because it has no seeds. It ends (cures) the piles and is useful for rheumatism [42].

The local people like dried fig in Mediterranean areas they contain Vit A, B1, B2, and vit C[43-45]. During storage condition the water activity of dried fruits will increase as the atmospheric relative humidity will be increases [46]. The figs are impure with Bacillus then cause bacteria at the level of 107e108 CFU/g dried figs [47].

Objectives of the study are to determine the suitable combination of temperature-and relative humidity for the control of test insects on stored Fig.

Review of Literature

Arthur (2001)[48] exposed the adults of Oryzaephilus surinamensis for 4 to 72 h on treated wheat with D.E after that removed and held on untreated wheat for 1 week. Adults exposed to D.E were held at 32, 27 and 220C, and relative humidity was 75, 57 and 40%. Results of the study showed that mortality after first exposures rose as temperature and exposure period increased but the effects of humidity were not consistent with temperature. Results indicated that O. surinamensis is sensitive to D.E and also suffer from exposure period and modified environment conditions

Mahroof et al (2003)[49] checked that increasing the temperature of a food-processing at 50–600C for 24–36 h can kill stored-product insects. Heat treatment and humidity may damage the developmental stages of the red flour beetle, Tribolium castaneum (Herbst). Temperature and relative humidity were provided with electronic steam heatersto eggs, young instars, old instars, pupae, and adults of T. castaneum at the same 10 locations within each mill. The relative humidity was 21% in most locations at 500C. The mortality of T. castaneum life stages was 100% in most locations, except in areas where temperatures were 500C. Old instars and pupae were found to be relatively more at tolerant as compared with other life stages.

Mendoza et al (2004)[50] studied the life cycle of Sitotroga cerealella in laboratory at different range of temperatures from 10 to 400C and relative humidity of 43 to 87%. no survival of any stage from 10 and 400C was found at any R.H. the main factor was temperature which responsible for egg hatching period, larval pupal growth time and egg, larval and pupal growth. The optimum abiotic conditions were observed for growths of S.cerealella were 75% R.h and 300C on corn.

Hassan et al (2005) [51] studied the impact of temperature on growth of Rhyzopertha dominica in stored wheat. Different genotypes of wheat were evaluated in laboratory at three levels of temperature i.e 30, 28 and 25˚C with 75% relative humidity. Data regarding number of damage grains, emergence of male and female, kernel weight loss and damage grains weight were documented in different genotypes after storage period of three months. Investigations revealed that weight of destructive kernels, male and female emergence and number of damaged seeds were positively correlated with weight loss of grains while the optimum temperature observed for maximum population development of R. dominica was 280C.

Salha, et al (2007) [52] determined the effect of low temperature for the control of insect pests of stored maize. F1 progeny of Rhyzopertha dominica and Sitophilus zeamais were cultured in laboratory and experiment was conducted in silo chamber at 60 0C. Higher morality of maize weevil was noticed after exposure period of 43 days while in case of lesser grain borer after 33 days same result was obtained. It was suggested that low temperature technique is cheap then Phosphine fumigation which usually required two treatment in a season for reinfestation of stored grains pests and also pollute the environment and treated products.

Ktys (2008) [53]performed lab research to determine the effect of periodically increased and short termed temperatures on the population dynamic of *Oryzaephilus surinamensis*. It was observed that increased temperature in both form periodical and short term responsible for population decline. Females were more sensitive to temperature increase as compared to males.

Al-Dosary (2009) [54] conducted lab experiments to check the effect of saw toothed beetle in date palm at various temperatures levels i.e 20,30 and 40°C after the storing period of one and two months. Results revealed that lowest date infestation and highest pest population suppressed at 40°C as compared to other temperature levels.

Strelecet *et al* (2010) [55] checked the four different environmental conditions of temperature and relatively humidity on three wheat cultivars packedin paper bags and stored for one year. During the first ninety days there is great reduction in grain moisture content of 4, 2.5 and 0.9 %, respectively, under 40 °C, 25 °C and 4 °C and relatively humidity of 45 % occurred. The germination ability of observed cultivarswas lost only under different storage temperatures. The seed germination and vigour loss occurred at 40°C, RH = 45 %after one year of storage than under 25°C, RH = 45%. The collected data indicated that there is significant influence of storage conditions on moisture content, germination and vigourness.

Santa-Cecilia *et al* (2011) [56] studied the survival of Pseudo coccuslongispinus in a laboratory at different temperatures of 35, 30, 25, 20 and 15° C. insects were enclosed in a petri dish having foliar disc of Coffea Arabica. It was noted that population survival and development of P. longispinus was affected by temperature. Small numbers of insect survive at 15 to 30° C whereas 100% death rate was observed at 35°C. The time period of nymphal phase was shorten when temperature increase from 20 to 25°C. While higher temperature increased the number of generations. Optimum temperature was 25°C for development of insect.

Jian *et al* (2012) [57] checked the spatial distribution and three dimensional temporal of Tribolium castaneum in wheat storage under different conditions of temperatures and population distributions. Three insect densities i.e low (0.1), medium (1.0) and high (5.0) adults per kg of wheat were resolute and three temperatures 30±1, 25±1 and 20±1 were used. Results of the experiment revealed that aggregation manners were decreased as insect population densities increase high adult cluster distributions were noticed at medium and low densities. Tested temperatures did not showed any effect on aggregation behavior of the test insect.

Hassan *et al*. (2013) [58] observed the impact of various humidities on population development of psocid Liposceli syunnaniensis. The four R.H levels i.e 75, 63, 55 and 43% were applied respectively. After 30 days periods it was noticed that population growth was high on 75 and 63% as compared to 55 and 43% where all the mature female of psocids died. Results of the experiments revealed that higher levels of humidity lead to highest population development whereas lower humidity levels responsible for the death of population and reduce the population development.

Riaz *et al* (2014) [59]checked the effect of various temperature range from 15-45oC and relatively humidity 60±5% on different life stages of the stored grain pest Trogoderma granarium. The adult female of khapra beetle survived at 25oC for 19.62±2.18 days but population is decreased when temperature increased. Adult male survived for 13.84±2.15 days at 20°C the population decrease when temperature is high. The large amount of eggs was laid at 35 and 30°C while egg laying capacity is decreased at temperatures of 40 and 20°C. Maturity of larvae, eggs hatching duration and emergence of adult was lowest at 35°C but development period extend at 25-30°C.larvae of test insect was not able to pupate at 40 and 20oC. The pupal and larval stages reduce at 35°C. The development duration was 36.53, 41.48 and 60.46 days at 35, 30 and 25oC respectively. It was concluded from the results of experiments that T. granarium could not able to complete its life cycle at 40 and 20°C whereas 35°C was the optimum temperature for development.

MATERIALS AND METHODS:

The study was conducted at the Grain Research, Training and Storage Management Cell, Department of Entomology, University of Agriculture Faisalabad during 2015-2016.

Collection of Insects:

Heterogeneous population of Tribolium *castaneum* was collected from grain market, godowns in Faisalabad.

Insect Culture: *T. castaneum* were reared on sterilized wheat grains and wheat flour, respectively, under laboratory conditions. Newly emerged adults of *T. castaneum* were introduced into jars containing disinfested wheat grains and wheat flour, respectively. Adults of the both insects were placed for three days in jars and the jars will be kept under optimum conditions 28±2ºC,RH: 65±5% to get homogenous population for the experiments.

Bioassay for population dynamic of *Tribolium castaneum*at different temperature levels and relative humidity.

For conducting bioassay method 36 glass jars of 12×20 cm dimensions those were tightly locked when they were used. In each jar 30 healthy figs were placed. In half of the jar, 20 adults of *Triboliu*m *castaneum* beetle were placed and the others were left free of the insects. The temperature that were used 20, 30, and 40ºC and the relative humidity arrange of 50±5% and 70±5%. In each group 6 jars were put in all the degrees of temperature and 3 jars were randomly chosen for each degree of temperature from both groups so as to test them after one and two months of incubation. The infected figs were identified and calculated by noticing the change in color, smell and shape of fig so as to assign and the number of living and dead insects was calculated to determine the rate of mortality, the population density of the *Tribolium castaneum* and the rate of infection.

$$\text{Rate of Mortality} = \frac{\text{No. Dead Insects}}{\text{Total No. of Insects}} \times 100$$

$$\text{Rate of Infection} = \frac{\text{No. of Infected Figs}}{\text{Total No. Figs}} \times 100$$

All the experiments were designed according to complete random design (C.R.D). Same procedure was adopted for trials of *Tribolium castaneum.*

RESULTS AND DISCUSSION:

As an alternative to chemical control modified abiotic conditions were evaluated to manage the destructive insect pests of stored products. Insecticidal impact of different levels of temperature and Relative humidity were studied under laboratory condition against *Tribolium castaneum* (Herbest). Three different levels of temperature i.e 20, 30 and 40^{0}C and two different humidities i.e 50±5% and 70±5% were used with different exposure periods of 30 and 60 days for percent mortality and infestation rate of the test insect species. Broken figs were used during experiment to check the infestation rate of test pests.

Table 1: Analysis of Variance Table of *Tribolium Castaneum* Infestation after 30 Days at 50%RH.

SOURCE	DF	SS	MS	F	P
TREATMENT	3	5347.40	1782.47	6.38	0.0162*
ERROR	8	2233.33	279.17		
TOTAL	11	7580.73			

Ns=Non significant (P>0.05) * Significant at (P<0.05) ** Highly significant at (P<0.01)The analysis of variance related with the prescribed relations of *Tribolium castaneum*. appeared to be significant for the mentioned patterns of humidity, infestation and time intervals of 30 days. The effects were significant at (P=0.0162) and (F=6.38)

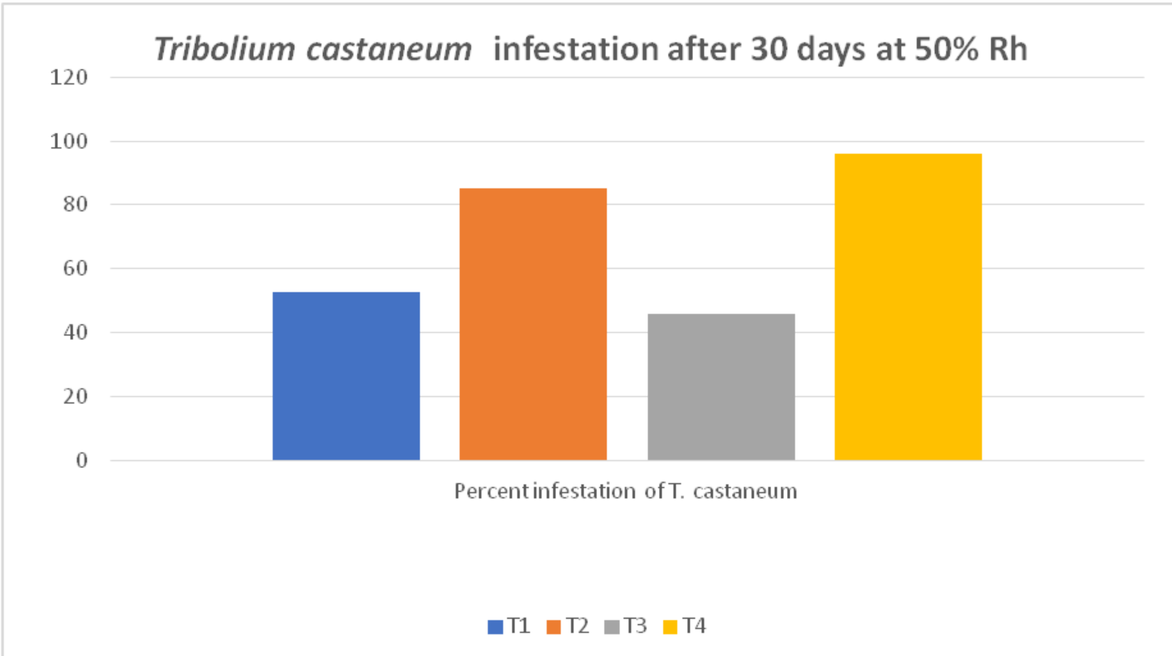
Table 2: Post HOC Tukey HSD All-Pairwise Comparisons Test of total infestation of *Tribolium castaneum* after 30 days at 50% R.H.

TREATMENTS	MEAN
T4 (CONTROL)	95.833 A
T2 (AT 30 ^{0}C)	85.000 AB
T1(AT 20 ^{0}C)	52.500 AB
T3 (AT 40 ^{0}C)	45.833 B

Mean sharing the same letters are non-significant at (P>0.05)

The post hoc Tukey HSD all-pairwise comparisons test of total infestation by treatment showed the significant effects in varying treatment means. The patterned relative characters showed the maximum infestation in treatment T4 with values 95.833 A and minimum was reported in treatment T3 with values 45.833 B. .

GRAPHICAL PRESENTATION OF *TRIBOLIUM CASTANEUM* INFESTATION AFTER 30 DAYS AT 50% R.H



- T1(at 20 ^{0}C)
- T2(at 30 ^{0}C)
- T3(at 40 ^{0}C)
- T4(control)

Table3: Analysis of variance table of *Tribolium castaneum* infestation after 30 days at 70%RH.

Source	DF	SS	MS	F	P
Treat	3	1318.75	439.583	5.70	0.0219
Error	8	616.67	77.083		
Total	11	1935.42			

Ns=Non significant (P>0.05) * Significant at (P<0.05) ** Highly significant at (P<0.01)The analysis of variance related with the prescribed relations of *Tribolium* spp. appeared to be significant for the mentioned patterns of humidity, infestation and time intervals of 30 days. The effects were significant at (P=0.0219) and (F=5.70)

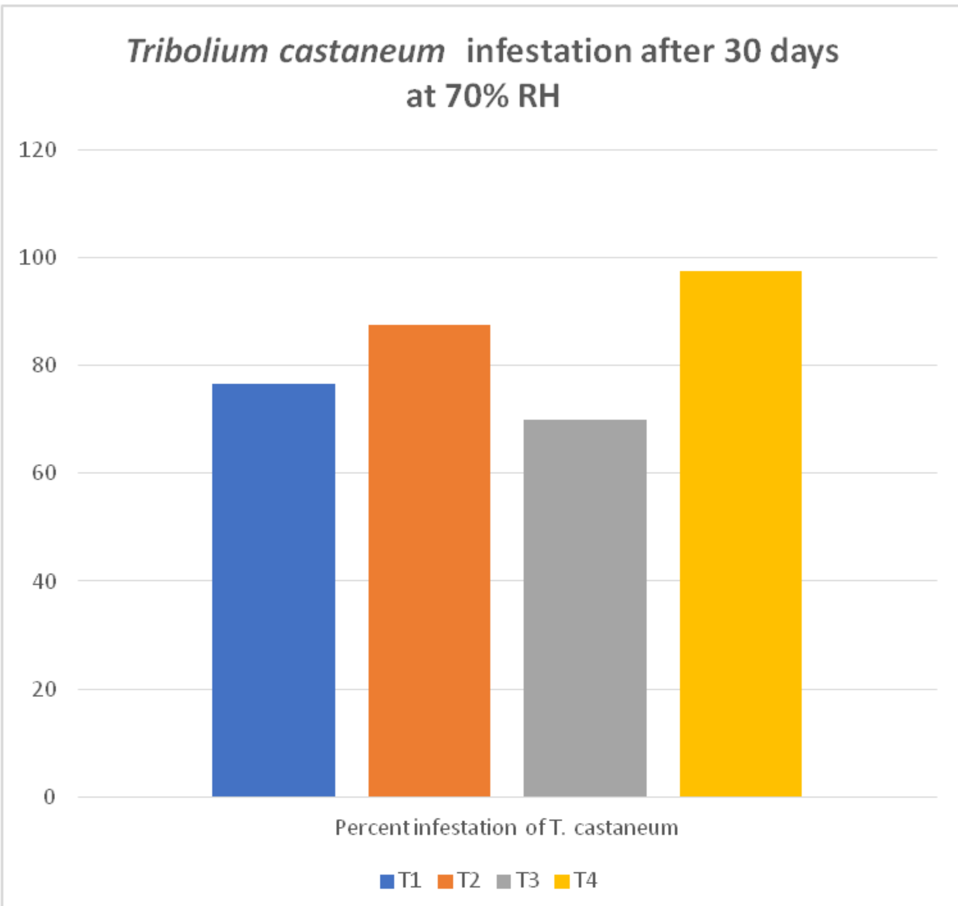
Table4: Post hOC tukey HSD all-pairwise comparisons test of total infestation of *Tribolium castaneum* after 30 days at 70% R.H.

Treatment	Mean
T4 (control)	97.500 A
T2 (at 30 ^{0}C)	87.500 AB
T1 (at 20 ^{0}C)	76.667 AB
T3 (at 40 ^{0}C)	70.000 B

Mean sharing the same letters are non-significant at (P>0.05)

The post hoc Tukey HSD all-pairwise comparisons test of total infestation by treatment showed the significant effects in varying treatment means. The patterned relative characters showed the maximum infestation in treatment T4 with values 97.500 A and minimum was reported in treatment T3 with values 70.000 B.

GRAPHICAL PRESENTATION OF *TRIBOLIUM CASTANEUM* INFESTATION AFTER 30 DAYS AT 70% RH.



DISCUSSION:

Abiotic conditions play a vital role for the development of insect pests to complete their life cycle and to cause severe losses during storage conditions. Temperature and relative humidity are the main factors for development of any insect population. From last seven decades insect pest controlling history has been written primarily by toxicologists and chemists after the astonishing success of chemicals after world war II. The extensive use of these chemicals put hazardous impact on all life forms and environment. In the present study as an alternative to chemicals modified abiotic conditions were used to manage the population of most destructive pest of stored products i.e *Tribolium castaneum* and Three levels of temperatures 20, 30 and 40^{0}C with interaction of 50 and 70% relative humidity were used during experimentation. The modified abiotic conditions were maintained for 30 days and test insect species were exposed to the above abiotic conditions for previously mentioned time periods. During experimentation the infestation rate of the tests insect pests species were noticed on the fig(FICUS CARICA).

In this study Infestation rate to stored fig after exposure period of 30 days caused by *Tribolium castaneum* was maximum with mean value of (87.50%) at 70% relative humidity with 30^{0}C and was minimum with mean value of (45.83%) at relative humidity of 50% with 40^{0}C Results of the findings showed similarity with (Ahmad *et al*., 1986; Navarro *et al*., 1978 and Ahmedani *et al*., 2011) [60-62], who described that insect population is positively correlated with infestation as relative humidity decreases and temperature increases the mortality increased which influence the infestation rate. Khattak *et al*.,(2000) [63] also reported that infestation rate and damage is correlated with insect pest population on higher temperature less population survive which results in less infestation rate.

From these findings it is concluded that modified abiotic conditions can be successfully used in integrated pest management strategies to overcome the use of hazardous chemicals in stored commodities.

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