International Journal of Horticulture, Agriculture and Food Science (IJHAF)
ISSN: 2456-8635
[Vol-9, Issue-1, Jan-Mar, 2025]
Issue DOI: https://dx.doi.org/10.22161/ijhaf.9.1
Peer-Reviewed Journal

Growth and Development of Oriental Fruit Fly *Bactrocera dorsalis* (Hendel) (Diptera: Tephritidae) Depends Upon Effects of Climate Change

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Received: 09 Dec 2024; Received in revised form: 06 Jan 2025; Accepted: 12 Jan 2025; Available online: 17 Jan 2025

Abstract— *The interrelationship between factors of climate change and oriental fruit fly Bactrocera dorsalis have not been investigated thoroughly in Nepal. Thus, a study was conducted to understand the effect of different factors of climate change on growth and development of oriental fruit fly B. dorsalis. The study was carried out in laboratory conditions of the Entomology department, Agriculture and Forestry University, Chitwan, Nepal where samples of oriental fruit fly B. dorsalis were collected and reared in the artificial condition. Oriental fruit flies B. dorsalis of a specific stage were tested in the environmental chambers to determine their interlinkage with fluctuating relative humidity and temperature. Sample insects were also kept in the chambers to detect their effect by variable carbon dioxide (CO_2). At 5^0c temperature the average numbers of B. dorsalis were 15, however, their growth and development changed leading to their numbers equal to 13 at 15^0c and 1 at 40^0c. The average numbers (i.e., growth and development) of oriental fruit fly B. dorsalis observed were non-significant with variable temperature. Growth and development of B. dorsalis found positively correlated with the relative humidity. Maximum development and increase in pest population detected between 60-70%. Relative humidity (RH). Growth and development of oriental fruit fly B. dorsalis were positively correlated with changing carbon dioxide (CO_2), however, significant increase in pest population found at 570 ppm carbon dioxide. Therefore, the factors of climate change found directly interrelated with the growth and development of oriental fruit fly Bactrocera dorsalis.*

***Keywords*— Carbon dioxide, Pest, Population, Relative humidity, Temperature**

I. INTRODUCTION

Oriental fruit fly, *Bactrocera dorsalis* (Hendel) (Diptera: Tephritidae) is considered as the most destructive pest of tropic areas which feeds on fruits and vegetables globally. This pest has more than 430 hosts with many economically important crops. Oriental fruit fly reflects trade barriers in while supply agricultural products to other countries [1, 2]. Although established in Hawaii since 1964 [3], *B. dorsalis* has not been observed on the U.S. mainland despite repeated incursions since its first detection in 1960 in California; but both the acceleration of both size and their frequency could be detected there. From 2018 in Florida the *B. dorsalis* have created huge loss on international trade and market through its decline in quality and quantity [4].

To reduce the impacts of fruit-fly the female fruit fly management programs that focus on their behavior and habits have been targeted [5]. The attraction of flies could be initiated where protein odor and host fruit odor (with two classes of volatile cues) would be applied for female fruit flies to focus protein-rich food sources and oviposition sites respectively [6], and thus may be explored as an attractant [7 8, 9, 10, 11]. The attraction of odor cues released for the use of female flies has been regarded as strong influence on food and host choice that female fruit fly makes through their physiological status (e.g., mating status, age, and hunger level) [12, 13]. It is also known that an unmated female fruit fly is regarded as highly responsive to protein-based odors, and a mated, sexually mature female fly are potentially attracted in host fruit-based odors [13, 14].

The B. dorsalis have remarkable developmental phase in olfactory behavior. After reaching male adults at sexual maturity, they attracted and forcefully consume methyl eugenol (4-allyl-1,2-dimethoxybenzene) [15]. Females observe to become more sensitive to extended variety of volatile compounds during the oviposition time and are attracted then to stimulate oviposition [16]. Such behavior of insect helps to study the optional strategy to manage the pest.

Climatic changes are assumed to affect the geographic extension of numerous organisms that also includes pests influencing their capacity to overwinter in new areas, with exploring heal and cold stress and transforming their growth and development at different circumstances [17]. The acceleration of global warming may further change or even expand the PGDs of non-native 79 species including fruit fly [18, 19].

Most of the olfactory, reproductive, attractive, growth, etc. behavior of oriental fruit fly depends on existing abiotic factors of environment. Oxygen plays a vital role in animal growth and development (Frazier et al., 2001). Some study also reflects that low oxygen affects the development of *Drosophila melanogaster* [21]. Minimizing oxygen concentration is a strategy that has been potentially used to manage postharvest pests at room temperature [22, 23]. Level of carbon dioxide have also been regarded as important factor for development and growth of oriental fruit fly *B. dorsalis.*

The increase in temperate due to global warming have shown multi-results on our ecosystem. Such transformation in temperature has both negative and positive aspects in feeding, reproduction, movement, oviposition, etc. behavior of the insect pest behavior [24, 25, 26]. Insects encounter frequent short-term episodes of fluctuating temperature. With changing climate, insect behaviors may change frequently. It is crucial to know the effect of changing climate in insect behavior and nature. Some implication in *B.* dorsalis may be that the pest populations generally rise during increased in some seasons [27, 28]. It has been investigated that *B. cucurbitae* adults can withstand the temperature of 41–47°C, however, higher than 51^{0}c make them lethal and inactive. Adults are always regarded to be useful at higher temperature [29].

Therefore, this study will be concerned on the growth and development of Oriental fruit fly *B.* dorsalis in changing climate.

II. MATERIALS AND METHODS

The study was carried out in laboratory condition of Entomology department, Agriculture and Forestry University, Chitwan, Nepal during January 2022 to December 2022. Samples of oriental fruit fly *B. dorsalis* were collected and reared in the artificial condition. Oriental fruit fly *B.* dorsalis of a specific stage were tested in the environmental chambers to understand relative humidity and temperature. Sample insects were also kept in the chambers to detect their relationship with variable carbon dioxide (CO_2). The test insect i.e. 30 laboratory reared pupae (1 day old) were placed in plastic containers (20 cm x18 cm) designed with three windows (6x4 cm) on the sides and one at the bottom covered with a cotton cloth to facilitate ventilation and balance of the temperature. All the stage of oriental fruit fly were reared in the laboratory condition and regularly monitored for the study. The tabulated data (with MS-Excel) were analyzed by using MSTATC package. Duncan's multiple range test (DMRT) was deployed to compare the mean at 5% level of significance.

III. RESULTS

Effect temperature in the population of oriental fruit fly *B. dorsalis*

It was recorded that there were 15 numbers of oriental fruit fly *B. dorsalis* before the monitoring. The average numbers of oriental fruit fly *B. dorsalis* transformed to 13, 13, 12, 10, 7, 4, and 1 at 10, 15, 20, 25, 30, 35, and 40^{0}c temperature. The mean value of pest was 9 at 21.250c mean temperature as in Figure 1.

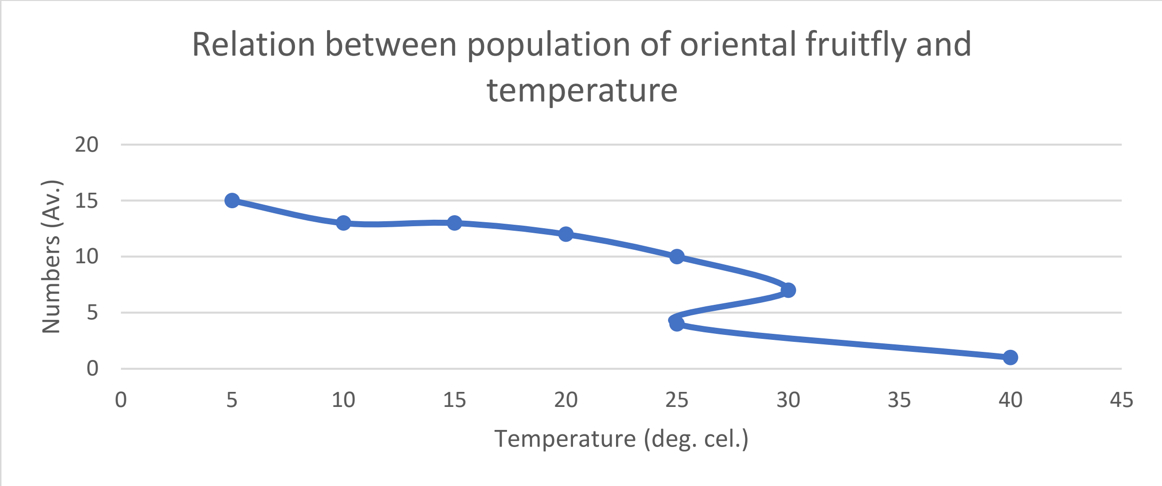

Fig. 1. Effect temperature in the population of oriental fruit fly B. dorsalis.

Effect of relative humidity (RH) in the population of oriental fruit fly *B. dorsalis*

It was found that at 10% relative humidity (RH) the average numbers of oriental fruit fly *B. dorsalis* were 15. The average numbers of oriental fruit fly *B. dorsalis* changed to 17, 20, 27, 32, 50 and 110 at relative humidity (RH%) 20, 30, 40, 50, 60 and 70 respectively. The mean value of oriental fruit fly *B. dorsalis* was 39 at 40 mean RH as described in Figure 2.

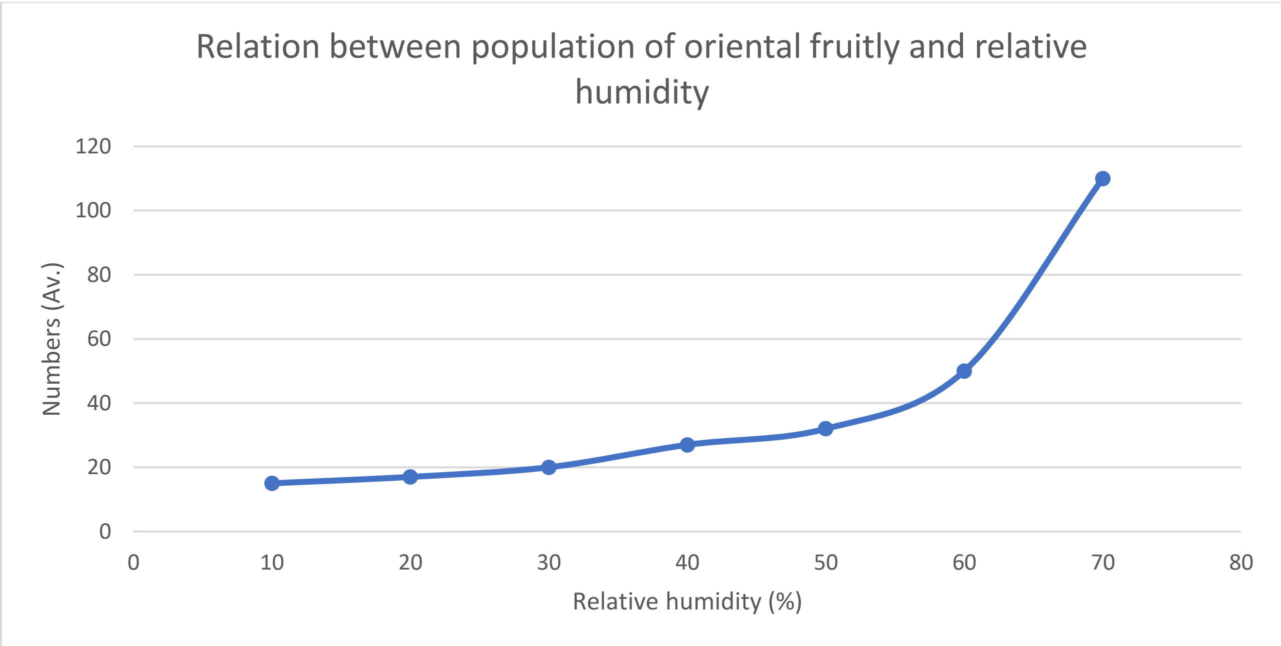

Fig. 2. Effect of relative humidity in the population of oriental fruit fly B. dorsalis

Effect of carbon dioxide (CO_2) in the population of oriental fruit fly *B. dorsalis*

It was found that in average 20 numbers of oriental fruit fly *B. dorsalis* were present at CO_2 380 ppm which were just 5 before recording. The number changed to 25, 37, and 55 at CO_2 (ppm) 440, 500, and 570 respectively as shown in Figure 3.

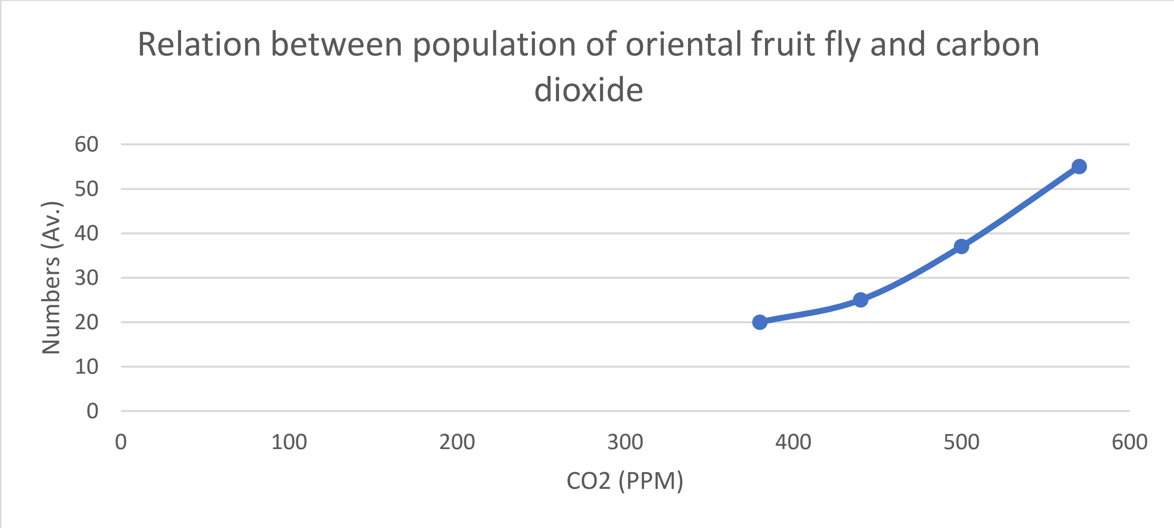

Fig. 3. Effect of carbon dioxide (CO_2) in the population of oriental fruit fly B. dorsalis

IV. DISCUSSION

Increase in temperature resulted decline in the population of oriental fruit fly *B. dorsalis.* After 25^0c their growth and development were potentially affected which thus lowered their numbers as well. In the present study growth (duration) was negatively influenced by temperature [30]. Investigation of Mohamed [31] also supported our result that the growth, fecundity, and development of fruit fly are negatively correlated with the increase in temperature. After certain temperature (i.e., higher 36^0c) the flies cannot withstand and become lethal. Study of Duyck and Quilici [32] found that there was a narrow reproduction and growth of larvae and adult of fruit flies while inkling the temperature. The studies of [33, 34, 35] confirms that oriental fruit fly was affected by increasing temperature, especially in their feeding, mating, movement, and growth habits. After certain temperature they become very inactive and stop their activities. Extreme high temperature is considered as relative concept, and these studies relates the implication of extreme high temperatures on flies that have targeted more on warming and heat waves, especially in summertime focus more to temperatures and heat waves that occur in summer that may hinder physiological and behavior of the pest.

The growth and development of oriental fruit fly *B. dorsalis* surged gradually with relative humidity. Highest population of oriental fruit fly *B. dorsalis* were observed at 60-70% RH. The study of Sahoo et al. [36] revealed that abiotic factors such as rainfall, RH, etc. have direct effect in the growth and development of fruit fly mass. In one of the study Bateman [37] described the ecological parameters such as relative humidity has influential effect in the reproduction and development of fruit fly species. Some relevant findings [38, 39, 40, 41, 42,43] and the thermal mortality rates [44, 45, 46, 47] also confirms that environmental factors such as relative humidity provides certain consequences in growth, fecundity, and development of oriental fruit fly.

The growth and reproduction of oriental fruit fly *B. dorsalis* raised with increasing carbon dioxide level. Highest activities and growth of oriental fruit fly *B. dorsalis* were observed at 380 ppm towards 570 ppm CO_2. It seems that insect pest could know the location of CO_2 sources such as plants and increase volume levels might influence the insect's CO_2-sensing system [48]. It has been observed that level of CO_2 may differentiate in varying insect categories and families such as lepidopteran larval duration consumed longer duration at raised CO_2 of 550 and 700 ppm on *Spodoptera litura* compared with ambient CO_2 [49]. In *Bactrocera tryoni*, the quantity of carbon dioxide stimulates and attracts in oviposition [50, 51]. It reflects that increased level of CO_2 have increased activities of insect *B. dorsalis* and significantly related with its growth and development; indicates our findings coincides with previous studies.

This could be related with the influencing improve in body system, physiology an immune of insect pest where and is because of higher fungal spore synthesis as noticed at the higher CO_2 concentrations [52]. Stange [51] found that oriental fruit fly require higher CO_2 and increased CO_2 have positive effect in development and reproduction of oriental fruit fly *B. dorsalis.*

V. CONCLUSION

The study was carried out in laboratory conditions of the Entomology department, Agriculture and Forestry University, Chitwan, Nepal during January 2022 to December 2022. Samples of oriental fruit fly *B. dorsalis* were collected and reared in the artificial condition. Oriental fruit flies *B.* dorsalis of a specific stage were tested in the environmental chambers to detect their interrelationship with relative humidity and temperature. Sample insects were also kept in the chambers to detect their relationship with variable carbon dioxide (CO_2). The average numbers (i.e., growth and development) of oriental fruit fly *B. dorsalis* observed are non-significant with temperature. Growth and development of *B. dorsalis* found positively correlated with the relative humidity. Maximum development and increase in pest population detected between 60-70%. Relative humidity (RH). Growth and development of oriental fruit fly *B. dorsalis* were positively correlated with carbon dioxide (CO_2), however, significant increase in pest population found at 570 ppm carbon dioxide.

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