Journal of Entomology and Zoology Studies

Available online at www.entomoljournal.com

J E Z S Journal of Entomology and Zoology Studies

E-ISSN: 2320-7078
P-ISSN: 2349-6800
JEZS 2017; 5(6): 1824-1827

Received: 05-09-2017
Accepted: 06-10-2017

Dr. Meena Kumari
Ph. D. Environment Science, Department of Environmental Science, Dr. Yashwant Singh Parmar University of Horticulture and Forestry, Nauni, Solan, Himachal Pradesh, India

Dr. Subhash Chander Verma
Principal Scientist, Department of Entomology, Dr. Yashwant Singh Parmar University of Horticulture and Forestry, Nauni, Solan, Himachal Pradesh, India

Correspondence
Dr. Meena Kumari
Ph. D. Environment Science, Department of Environmental Science, Dr. Yashwant Singh Parmar University of Horticulture and Forestry, Nauni, Solan, Himachal Pradesh, India

Effect of elevated CO_2 and temperature on leaf damage caused by *S. litura* and infestation of green peach aphid, *Myzus persicae* Sulzer in bell pepper

Meena Kumari and Subhash Chander Verma

Abstract
Rising level of atmospheric CO_2 as a result of increasing emissions will affect the plant foliage quantity as well as quality, which could result in greater effect on the life cycle of insect herbivores. So the field experiment was conducted during 2014 and 2015 to study the effect of elevated CO_2 and temperature on per cent leaf damage caused by *S. Litura* and infestation caused by *Myzus persicae* to bell pepper plants grown under four concentrations of CO_2 and temperature, viz. three Open Top Chambers, (T_1: OTC with elevated CO_2 550±10 ppm; T_2: OTC with elevated temperature 1˚C higher and elevated CO_2 550±10 ppm; T_3: OTC with ambient temperature and CO_2 (reference) as well as under T_4: natural ambient air and temperature in open. Biochemical analysis of foliage revealed that plants grown under elevated CO_2 had lower nitrogen which caused an increase in food consumption by *S. litura* in order to compensate their nutritional requirement and hence resulted in more infestation as compared to ambient CO_2 and temperature and natural condition. Also elevated CO_2 and temperature resulted higher number of aphids on bell pepper plants which may be due to elevated CO_2 and temperature which favours better growth of aphids under denser plant canopy and humid conditions.

Keywords: *Capsicum annuum* L., elevated CO_2, elevated temperature, consumption, open top chamber, *Spodoptera litura*, *Myzus persicae* Sulzer

1. Introduction

Climate change, especially rise in temperature and atmospheric carbon dioxide concentration, is a major concern today. The concentration of CO_2 in the atmosphere may rise to 550 ppm by as early as 2035 [1]. The effects of climate change on insect pests can be both direct and indirect. Many plant species respond to enriched atmospheric CO_2 by enhanced photosynthetic rates and the increase in biomass [2] as well as alterations in leaf quality factors. The effects of the climate change on insect pests can be both direct and indirect. This might affect the growth of leaf eating insects through altered consumption and digestibility [3]. However, the positive effect of elevated CO_2 might be offset by the adverse effect of associated global warming particularly excessive heat and drought [4]. Report of Working Group II of IPCC indicated a probability of 10-40 per cent loss in crop production in India with increase in temperature by 2080-2100 [5].

Temperature, which impacts the development time, longevity and fecundity of insects has a direct effect while elevated CO_2 (eCO_2) has an indirect host- mediated effect on growth and development of insect pests [6, 7]. In plants grown in enriched CO_2 condition, reduction in leaf nitrogen can result in a nutritionally depleted food source for leaf eating insects [8]. Because leaf nitrogen is considered essential for growth and reproduction of insects [9] a reduction in nitrogen content of leaves grown under elevated CO_2 may elicit strong responses from them. As a consequence of these tight ecological linkages, the interplay between plants and herbivorous insects in the tropics can be affected by the perturbations of climate change.

Most published studies on response of insect herbivores to feeding on plants grown under eCO_2 have been short term experiments, quantifying the consumption and developmental rates of larvae of a single generation [10]. A few studies – *Gastrophysaviridae* on *Rumexobtusifolius* and *Neophilaenuslineatus* on *Juncussquarrosus* [11]; *Helicoverpa armigera* on wheat [12], on transgenic cotton [13] and on maize have addressed the impact of elevated CO_2 on multiple generations of herbivore insects.

Vegetable cultivation in Himachal Pradesh has gained significant importance on account of favorable agro-climatic conditions for growing quality off-season vegetables. In Himachal Pradesh, bell pepper (*Capsicum annuum* L.) is the most widely produced and consumed vegetable. In Himachal Pradesh, bell pepper was grown in an area of 2,408 hectares with an annual production of about 55,252 metric tonnes respectively, during 2015 [14]. The mid hill zone of Himachal Pradesh is endowed with highly congenial climatic conditions for vegetable production. This produce fetches a high price in plain markets and thus encourages Himachal growers to take up vegetable cultivation as a profession. However increasing level of CO_2 and temperature is affecting the growth, development and plant biochemistry of bell pepper in this region and hence influence insect-plant interactions which can cause drastic reductions in commercial yield and affect the livelihood of farmers. The effect of elevated atmospheric CO_2 on leaf quality of bell pepper and its impact on growth characteristics of *S. litura* is reported here. The tobacco caterpillar, *S. litura* occur during early and late stages of growth of bell pepper respectively. Larvae feed on the foliage and complete their life cycle. During outbreaks, it causes extensive defoliation, affecting gross photosynthesis. Similarly aphids infestation also causes huge dame to plant and affects the yield of bell pepper. The present studies aimed to understand the effect of elevated CO_2 and temperature on per cent leaf damage caused by *S. litura* and infestation of green peach aphid, *Myzus persicae* Sulzer in bell pepper.

2. Materials and methods

The present investigation was conducted at experimental farm of Department of the Environmental Science, Dr. Yashwant Singh Parmar University of Horticulture and Forestry, Nauni, Solan, India in the year 2014 and 2015. Farm is situated at 30˚5'N latitude and about 77˚11'E longitudes and at an elevation of 1260 m above mean sea level. Circular type open top chambers (OTC) of 4 x 4 m^2dimension were used to raise the crop under elevated and ambient CO_2 and temperature conditions. An automatic CO_2 enrichment and temperature technology was developed by adapting software SCADA to automatically maintain the desired and accurate levels of CO_2 and temperature around the crop canopy inside OTCs.Carbon dioxide gas was supplied to the chambers and maintained at set levels using manifold gas regulators, pressure pipelines, solenoid valves, rotameters, sampler, pump, CO_2 analyzer, PC linked Program Logic Control (PLC) and Supervisory Control and Data Acquisition (SCADA). The concentration of CO_2 in the chamber was monitored by a non dispersive infrared (NDIR) gas analyser. There were four treatmentsi.e.T_1: elevated CO_2 (550 ±10 ppm), T_2: elevated CO_2 and temperature (CO_2:550 ±10 ppm, temperature: 1°C elevated than T_1), T_3: ambient temperature (reference) and T_4: natural air and temperature condition (control).The bell pepper crop was transplanted during crop growing season in 2014 and 2015 under all the four conditions by following recommended package of practices of vegetable crops [15].

For the estimation of damage caused by insect total damaged leaves of bell pepper caused by *S. litura* was recorded in five randomly selected plants in each replication of both varieties in each treatment. The mean values were taken into account and percentage of leaves damage was worked out. The population of aphids in bell pepper was recorded on three leaf basis one each from lower, middle and upper leaf sample from each plant and mean aphid population was counted. The observations were recorded in five randomly selected plants in each replication of both varieties in each treatment. Data on these various parameters was recorded by following stranded procedures in Factorial Randomized Block Design and their mean values were utilized for statistical analysis as per the standard method [16]. The pooled analysis was made from two years data to assess the effect. The data recorded on different parameters were analyzed statistically with the help of Statistical Product and Service Solutions (SPSS- 21) Statistics 21.

3. Results and Discussion

3.1 Leaf damage caused by *S. litura*

The tobacco caterpillar, *S. litura* cause damage to leaf as well as fruit of the bell pepper. It is evident from Table 1 that during 2014, per cent leaf damage by *S. litura* was recorded maximum on plants grown under elevated CO_2 (14.78%) which differed statistically with elevated CO_2 and temperature (11.52%), ambient CO_2 and temperature (8.78%) and natural condition (1.88%).

Table 1: Effect of elevated CO_2 and temperature on per cent leaf damaged (%) caused by of *S. litura* in bell pepper

Treatment	Leaf damage by *S. litura*								
	2014			2015			Pooled		
	Variety								
	California Wonder	Solan Bharpur	Mean	California Wonder	Solan Bharpur	Mean	California Wonder	Solan Bharpur	Mean
T_1 : Elevated CO_2 (550±10 PPM)	15.23 (3.89)	14.33 (3.77)	14.78 (3.83)	14.50 (3.80)	14.00 (3.72)	14.25 (3.76)	14.87 (3.84)	14.17 (3.75)	14.52 (3.80)
T_2 : Elevated CO_2 and elevated temp (550±10 PPM & 1˚C)	11.27 (3.35)	11.76 (3.42)	11.52 (3.39)	21.40 (3.21)	12.00 (3.44)	11.20 (3.32)	10.83 (3.28)	11.88 (3.43)	11.35 (3.36)
T_3 : Ambient CO_2 and temperature	9.23 (3.03)	8.33 (2.88)	8.78 (2.95)	6.00 (2.44)	8.63 (2.93)	7.32 (2.68)	7.62 (2.74)	8.48 (2.90)	8.05 (2.82)
T_4 : Natural condition (control)	2.10 (1.42)	1.67 (1.28)	1.88 (1.35)	2.33 (1.52)	1.43 (1.18)	1.88 (1.35)	2.22 (1.47)	1.55 (1.23)	1.88 (1.35)
Mean	9.45 (2.92)	9.02 (2.84)	9.24 (2.88)	8.30 (2.74)	9.02 (2.82)	8.66 (2.78)	8.88 (2.83)	9.02 (2.83)	8.95 (2.83)
CD (p =0.05)	Treatment: 0.29 Variety: NS Treatment × Variety: NS			Treatment: 0.34 Variety: NS Treatment × Variety: NS			Treatment: 0.21 Variety: NS Treatment × Variety: NS		

*Figures in parenthesis are square root transformed values

Similarly, during 2015 plants grown under elevated CO_2 recorded significantly higher leaf damage (14.25%) followed by elevated CO_2 and temperature (11.20%), ambient CO_2 and temperature (7.32%) and natural condition (1.88%). Irrespective of years, the analysis of pooled data (Table 1) revealed that maximum damage on bell pepper leaves was recorded under elevated CO_2 (14.52%) which differed statistically with elevated CO_2 and temperature (11.35%), ambient CO_2 and temperature (8.05%) and natural condition (1.88%).

In the present findings, lower foliar nitrogen content under elevated CO_2 caused an increase in food consumption by *S. litura* in order to compensate their nutritional requirement and hence resulted in more infestation as compared to ambient CO_2 and temperature and natural condition. The present results are in consonance with the findings [17] that higher infestation of pea nut (*Arachis hypogea*) by *S. litura* was observed under elevated CO_2 over ambient CO_2. Similarly [18] reported that consumption of mung bean (*Vigna radiata* L. Wilczek) leaves by tobacco caterpillar (*S. litura*) was more under enriched CO_2 as compared to ambient CO_2.

3.2 Aphid population (*Myzus persicae* Sulzer)

Aphids cause huge damage to crops by affecting vegetative part of the plant and ultimately affects the yield of bell pepper crop. Data presented in Table 2 revealed that during 2014, amongst all treatments higher number of aphids (16.83 aphids/plant) on the plant were recorded under elevated CO_2 and temperature, which was statistically different from elevated CO_2 (9.17 aphids/plant), ambient CO_2 and temperature (8 aphids/plant) and natural condition (3.50 aphids/plant). No doubt, the trends were reported on other crops by various workers yet similar results were recorded in bell pepper also.

Table 2: Effect of elevated CO_2 and temperature on aphid population (number/plant) in bell pepper.

Treatment			Aphid population								
			2014			2015			Pooled		
			Variety								
			California Wonder	**Solan Bharpur**	**Mean**	**California Wonder**	**Solan Bharpur**	**Mean**	**California Wonder**	**Solan Bharpur**	**Mean**
T_1	:	Elevated CO_2 (550±10 PPM)	8.33 (2.96)	10.00 (3.20)	9.17 (3.08)	11.67 (3.48)	12.00 (3.50)	11.83 (3.49)	10.00 (3.22)	11.00 (3.35)	10.50 (3.29)
T_2	:	Elevated CO_2 and elevated temp (550±10 PPM & 1°C)	15.67 (4.01)	18.00 (4.29)	16.83 (4.15)	17.00 (4.15)	17.67 (4.25)	17.33 (4.21)	16.33 (4.08)	17.83 (4.27)	17.08 (4.18)
T_3	:	Ambient CO_2 and temperature	7.33 (2.79)	8.67 (2.93)	8.00 (2.86)	10.67 (3.34)	12.67 (3.62)	11.66 (3.48)	9.00 (3.06)	10.67 (3.28)	9.83 (3.17)
T_4	:	Natural condition (control)	3.00 (1.78)	4.00 (2.08)	3.50 (1.93)	5.33 (2.40)	6.00 (2.54)	5.66 (2.47)	4.17 (2.09)	5.00 (2.31)	4.58 (2.20)
Mean			8.58 (2.88)	10.17 (3.13)	9.37 (3.01)	11.17 (3.35)	12.08 (3.48)	11.62 (3.41)	9.87 (3.11)	11.12 (3.30)	10.50 (3.21)
CD (p =0.05)			Treatment: 0.64 Variety: NS Treatment × Variety: NS			Treatment: 0.40 Variety: NS Treatment × Variety: NS			Treatment: 0.36 Variety: NS Treatment × Variety: NS Year : 1.58		

*Figures in parenthesis are √n+0.5 transformed values

Similar trend was observed during 2015, where data revealed that number of aphids per plant was recorded higher (17.33 aphids/plant) under elevated CO_2 and temperature which was statistically different from the aphids population on plants under elevated CO_2 (11.83 aphids/plant), ambient CO_2 and temperature (11.66 aphids/plant), the last two treatments were statistically at par with each other. Natural condition (5.66 aphids/plant) recorded minimum aphid's population. Amongst all treatments (Table 2) higher number of aphids were observed on plants grown under elevated CO_2 and temperature (17.08 aphids/plant) which was statistically different from elevated CO_2 (10.50 aphids/plant), ambient CO_2 and temperature (9.83 aphids/plant) and natural condition (4.58 aphids/plant).

In the present investigations, elevated CO_2 and temperature resulted higher number of aphids on bell pepper plants which may be due to elevated CO_2 and temperature which favours better growth of aphids under denser plant canopy and humid conditions. The results are in accordance with the findings [19] that aphid abundance increases with an increase in CO_2 and temperature.

4. Conclusion

The present investigations indicated that elevated CO_2 and elevated temperature negated the positive effects of elevated CO_2 in the crop. Incidences of insect-pest were higher under elevated CO_2 and temperature as well as under elevated CO_2. Lower foliar nitrogen content under elevated CO_2 caused an increase in damage by *S. litura* in order to compensate their nutritional requirement and hence resulted in more infestation as compared to other ambient and natural condition as well as elevated CO_2 and temperature also favors the better growth of the aphids under denser plant canopy and humid conditions which resulted more crop loss in changing climatic conditions.

5. Acknowledgement

Authors are thankful to the financial support granted by the Department of the Environmental Science, Dr YS Parmar University of Horticulture and Forestry, Nauni, Solan, Himachal Pradesh.

6. References

1. Stern N. The economics of climate change: The stern Review, Cambridge, UK: Cambridge University Press, 2007.
2. Bazzaz FA. The response of natural ecosystems to the rising CO_2 levels. Annual Review of Ecology and Systematic. 1990; 21:167-196.
3. Lincoln DE, Fajer FD, Johnson RH. Plant-insect

herbivore interaction in elevated CO_2 environments. Trend Ecology and Evolution. 1993; 8:64-68.

4. Wang X, Lanzhu Ji, Guiqing W, Yan L. Potential effects of elevated CO_2 on leaf-feeding forest insects. Frontier of Biology in China. 2008; 3(1):68-77.
5. Aggarwal PK. Climate change: implications for Indian agriculture. In: Impact assessment of climate change for research priority planning in horticultural crops (ed, Lal SS.), Central Potato Research Institute, Shimla, 2008, 1-10.
6. Hunter MD. Effects of elevated atmospheric carbon dioxide on insect-plant interactions. Agricultural and Forest Entomology. 2001; 3:153-159.
7. Yadugiri VT. Climate change: the rote of plant physiology. Current Science. 2010; 99:423-25.
8. Lindroth RL, Kinney KK, Platz CL. Responses of deciduous trees to elevated atmospheric CO_2: productivity, photochemistry and insect performance. Ecology. 1993; 74:763-777.
9. Mattson WJ. Herbivory in relation to plant nitrogen content. Annual Review of Ecology and Systematics. 1980; 11:119-161.
10. Bezemer TM, Jones TM. Plant-insect herbivore interactions in elevated atmospheric CO_2: quantitative analysis and guild effects. Oikos. 1998; 82:212-22.
11. Brooks GL, Whittaker JB. Responses of multiple generations of *Gastrophysa viridula*, feeding on *Rumex obtusifolis*, to elevated CO_2. Global Change Biology. 1998; 4:63-75.
12. Wu G, Chen FJ, Ge F. Response of multiple generations of cotton bollworm *Helicoverpa armigera* Hubner, feeding on spring wheat to elevated CO_2. Journal of Applied Entomology. 2006; 130:2-9.
13. Chen FJ, Wu G, Lu J, Ge F. Effects of elevated CO_2 on the foraging behavior of cotton bollworm, *Helicoverpa armigera.* Insect Science. 2005; 12:359-365.
14. DOA. Area and production of vegetable crops in Himachal Pradesh. State Department of Agriculture, Government of Himachal Pradesh, Shimla, 2016.
15. YSPUHF. Package of practices for vegetable crops. Directorate of Extension education, Dr. YS Parmar University of Horticulture and Forestry, Nauni, Solan-173230, HP, 2009, 202.
16. Gomez KA, Gomez AA. Statistical Procedures for Agricultural Research, 2nd ed, John Wiley & Sons Inc., New York, 1983, 37.
17. Rao MS, Manimanjari D, Vanaja M, Rama Rao CA, Srinivas K, Rao VUM *et al*. Impact of elevated CO_2 on tobacco caterpillar, *Spodoptera litura* F. on peanut, *Arachis hypogea.* Journal of Insect Science. 2012; 12:103.
18. Srivastava AC, Tiwari LD, Pal M, Sengupta UK. CO_2 mediated changes in mung bean chemistry: Impact on plant–herbivore interactions. Current Science. 2002; 82(9):1148-1151.
19. Freier B, Triltsch H. Climate chamber experiments and computer simulations on the influence of increasing temperature on wheat-aphid-predator interactions. Aspects of Applied Biology. 1996; 45:293-298.