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Influence Of Climate Change On Insect Dynamics

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Introduction

Climate change refers to long-term shifts in temperatures and weather patterns. These shifts may be natural, human made or primarily due to using of non renewable sources of energies like coal, oil and gas as a energy sources (UN Climate Conference, 2022). Causes of the changing climate have been categorized into two groups *i.e*., anthropogenic causes (chemical fertilizer, deforestation, vehicle emission, industries) and natural causes (sun cycle, ocean current, forest fires, volcanic eruption, methane emission)

Climate change affects humans (Displaced people, poverty, loss of livelihood, malnutrition, risk of diseases, global food and water shortage) and animals (Habitat loss, migration, species loss). Similarly, it has a measurable impact on insects.

How do insect pests respond to climate change?

Climate change has an immediate and indirect impact on agricultural crops and pests. Climate change has direct effects on pest reproduction, development, survival and spread, while it indirectly influences the connections between pests, their habitat and other species of insects such as natural enemies, rivals, vectors and mutualists.

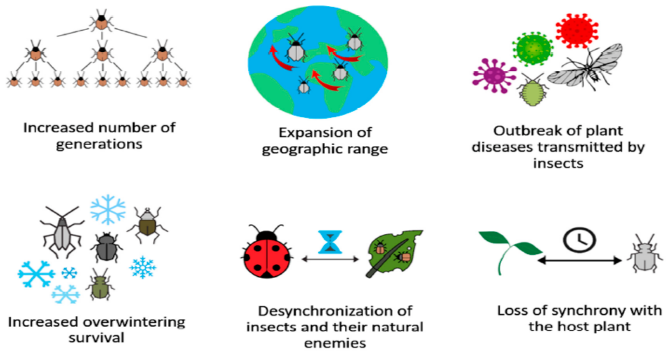

Fig.1: Climate Change’s Impact on Insects (Skendzic et al*.,* 2021)

Greater number of generations: Insect physiology is particularly sensitive to temperature fluctuations and their metabolic rate nearly doubles with a 10°C increase. As a result of global warming and the present temperature level, which is already near to the optimum for pest formation and growth, populations of insects in tropical zones are expected to see a decline in growth rate. In contrast, insects in temperate zones are projected to develop at a faster pace.

Expansion of geographical range: The Southern pine beetle, a deadly insect pest entering North America, is migrating north as temperatures increase and it is expected to spread over the North Eastern United States as well as southern Eastern Canada by 2050.

Outbreak of diseases of plants carried by insects: In general, disease carrying insects are homopterous, such as thrips and when temperatures rise, the number of generations rises, as does the rate of disease transmission.

Desynchronization of insects and their natural enemies: high temperatures and CO_2 levels affected the nutritional characteristics of alfalfa plants (*Medicago sativa* L.), which serve as hosts for the Beet armyworm

(*Spodopteraexigua* Hubner). Because of the lower nutritional components of the host plants, the larvae of *S. exigua* developed more quickly. At the same time, the larvae of its natural nemesis, the parasitic wasp (*Cotesiamarginiventris* Cresson), were unable to properly develop, resulting in the demise of the *C. marginiventris* population in the area.

Loss of synchronization with the host plant: The winter moth (*Operoptherabrumata*), hatches its eggs during the bud bursting phase of its host plant oak (*Quercusrobus*). Although a 2°C rise in temperature is unlikely to significantly alter the time of bud burst, the timing of larval hatching did not change, which is harmful for the moth and might lessen this specific pest problem.

The impact of climatic change on the tri-trophic relationship of the plant, plant herbivore and natural enemy.

The tri-trophic interaction of cotton (*Gossypium hirsutum*), *Aphis gossypii* (plant herbivore), and *Leis axyridis* (natural enemy) was altered by more CO$_2$ and these tests were performed at three distinct levels of CO$_2$ concentration (Chen *et al.*, 2015).

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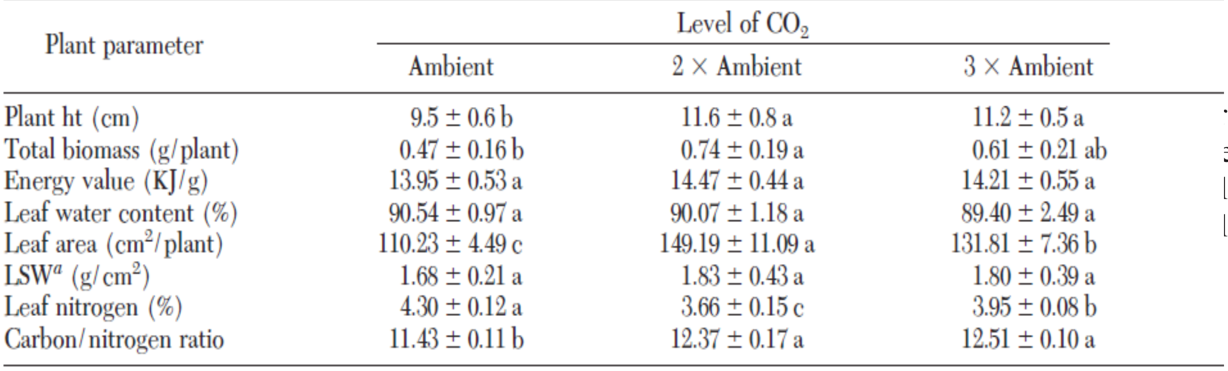
Results:



Plant parameter	Level of CO$_2$		
	Ambient	2 × Ambient	3 × Ambient
Plant ht (cm)	9.5 ± 0.6 b	11.6 ± 0.8 a	11.2 ± 0.5 a
Total biomass (g/plant)	0.47 ± 0.16 b	0.74 ± 0.19 a	0.61 ± 0.21 ab
Energy value (KJ/g)	13.95 ± 0.53 a	14.47 ± 0.44 a	14.21 ± 0.55 a
Leaf water content (%)	90.54 ± 0.97 a	90.07 ± 1.18 a	89.40 ± 2.49 a
Leaf area (cm^2/plant)	110.23 ± 4.49 c	149.19 ± 11.09 a	131.81 ± 7.36 b
LSW^a (g/cm^2)	1.68 ± 0.21 a	1.83 ± 0.43 a	1.80 ± 0.39 a
Leaf nitrogen (%)	4.30 ± 0.12 a	3.66 ± 0.15 c	3.95 ± 0.08 b
Carbon/nitrogen ratio	11.43 ± 0.11 b	12.37 ± 0.17 a	12.51 ± 0.10 a

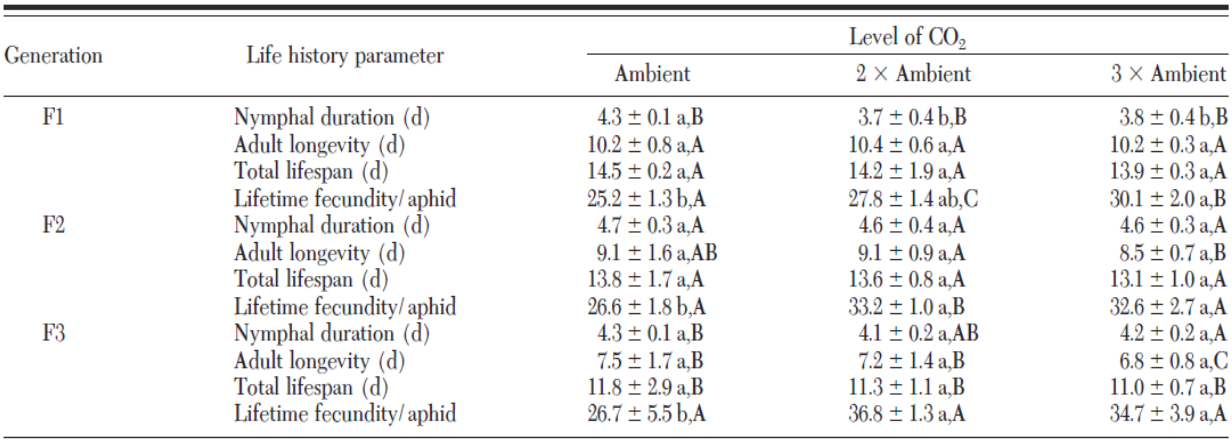
Table 1: Influence of rising levels of CO$_2$ on *Gossypium hirsutum*

Table 1 reveals that the percentage of CO$_2$ in the atmosphere had a substantial effect on *Gossypium hirsutum* leaf area, height, foliar N content, total biomass, and C:N ratio. Carbon : Nitrogen ratio and Plant height rose considerably on doubled CO$_2$ concentrations relative to the ambient environment. However, a three-fold increase in CO$_2$ concentration showed no effect on plant height on comparison with two-fold rise. Total biomass grew greatly when CO$_2$ levels were doubled, however additional elevations in CO$_2$ concentration resulted in lesser total biomass than other concentrations. Percentage of leaf wetness reduced somewhat as CO$_2$ concentrations increased, with no significant difference.

Experiment 2: Influence of rised CO$_2$ on Life Cycles of Aphid

The purpose of the present experiment was to assess the influence of CO$_2$ on aphid's three consecutive generations via host plant. On 30 days of CO$_2$ exposure, randomly thirty pots from chamber were selected randomly. From the stock colony, five apterous adolescent aphids were selected at random and placed on the bottom side of every plant.

Results:



Generation	Life history parameter	Level of CO_2		
		Ambient	2 × Ambient	3 × Ambient
F1	Nymphal duration (d)	4.3 ± 0.1 a,B	3.7 ± 0.4 b,B	3.8 ± 0.4 b,B
	Adult longevity (d)	10.2 ± 0.8 a,A	10.4 ± 0.6 a,A	10.2 ± 0.3 a,A
	Total lifespan (d)	14.5 ± 0.2 a,A	14.2 ± 1.9 a,A	13.9 ± 0.3 a,A
	Lifetime fecundity/ aphid	25.2 ± 1.3 b,A	27.8 ± 1.4 ab,C	30.1 ± 2.0 a,B
F2	Nymphal duration (d)	4.7 ± 0.3 a,A	4.6 ± 0.4 a,A	4.6 ± 0.3 a,A
	Adult longevity (d)	9.1 ± 1.6 a,AB	9.1 ± 0.9 a,A	8.5 ± 0.7 a,B
	Total lifespan (d)	13.8 ± 1.7 a,A	13.6 ± 0.8 a,A	13.1 ± 1.0 a,A
	Lifetime fecundity/ aphid	26.6 ± 1.8 b,A	33.2 ± 1.0 a,B	32.6 ± 2.7 a,A
F3	Nymphal duration (d)	4.3 ± 0.1 a,B	4.1 ± 0.2 a,AB	4.2 ± 0.2 a,A
	Adult longevity (d)	7.5 ± 1.7 a,B	7.2 ± 1.4 a,B	6.8 ± 0.8 a,C
	Total lifespan (d)	11.8 ± 2.9 a,B	11.3 ± 1.1 a,B	11.0 ± 0.7 a,B
	Lifetime fecundity/ aphid	26.7 ± 5.5 b,A	36.8 ± 1.3 a,A	34.7 ± 3.9 a,A

Table 2: Effects of increased CO_2 on ahid life cycles

In all three CO_2 treatments, the development period of *A. gossypii* differed considerably across generations. Fecundity rose when CO_2 concentrations increased, although the impact was more significant in the second and third generations (Table 2).

Experiment 3: The influence of rised CO_2 on the Life Cycle of a Lady Beetle

When the aphids attend population of 100 per plant, five aphid-infected pots were chosen at random from each room and each of them received one freshly hatched lady beetle larva. The plant which were treated with lady beetles was surrounded by gauze cages. Individual larvae were monitored on a daily basis to evaluate moulting and death. Following each molt, the larvae's total body mass was determined with an automated electro-balance, a Cahn 20.

Results:

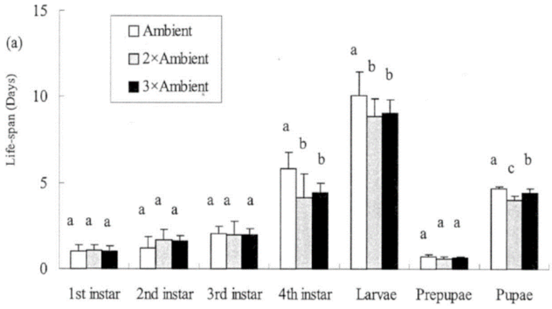


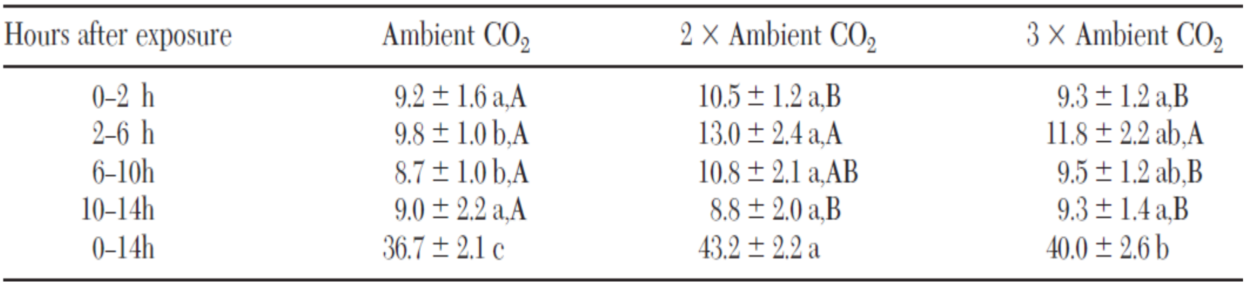
Fig. 2: Impact of rised CO_2 levels on life cycle of lady beetle

The development times of *L. axyridis*-fed aphids from the three CO_2 regimens were similar for the initial three instars. However, the fourth instar, total larval length, and pupal stage were substantially shorter, when fed on aphids under elevated CO_2 regimens as opposed to optimum CO_2 regimes (Fig. 2).

Experiment 4: Impact of rised levels of CO_2 on Lady Beetle Prey Preferences

Day 45 of plant development witnessed the random selection of two pots from the chamber and the planting of fifty third-instar aphids on matching patches in each landscape, with a random selection made from individual three CO_2 treatments. One mature lady beetle that had just emerged was placed in each landscape. The count of number of aphids consumed by each lady beetle on each patch was recorded at different time periods (2, 6, 10, and 14 hours) after the beetles were exposed to the landscape.

Results:



Hours after exposure	Ambient CO_2	2 × Ambient CO_2	3 × Ambient CO_2
0–2 h	9.2 ± 1.6 a,A	10.5 ± 1.2 a,B	9.3 ± 1.2 a,B
2–6 h	9.8 ± 1.0 b,A	13.0 ± 2.4 a,A	11.8 ± 2.2 ab,A
6–10h	8.7 ± 1.0 b,A	10.8 ± 2.1 a,AB	9.5 ± 1.2 ab,B
10–14h	9.0 ± 2.2 a,A	8.8 ± 2.0 a,B	9.3 ± 1.4 a,B
0–14h	36.7 ± 2.1 c	43.2 ± 2.2 a	40.0 ± 2.6 b

Table 3: Influence of rised CO_2 on prey priorities by lady beetles

During a 14-hour feeding trial, adult *L. axyridis* consumed significantly more cotton aphids in the two and three ambient CO_2 patches. Where the intensity of intake on the optimum CO_2 patch was the lowest. After being exposed to the treatment landscape for two to six hours, lady beetle aphid consumption rised by 20% in the three ambient CO_2 patch and by 33% in the two ambient CO_2 patch compared to the standard CO_2 patch. In contrast to the ambient CO_2 patch, lady beetles absorbed 3% more on three ambient CO2patches and 17% more on two ambient CO2patches during the course of the 14-hour feeding. (Table 3).

This work provides preliminary experimental proof on variations in prey, fed on host plants cultivated at various CO_2 levels can play affect on the diet preferences of their natural predators.

Conclusion

Climate change is the most serious issue confronting the planet today. Global warming is becoming worse by the day. If we do not stop it as quickly as possible, our world will suffer the consequences and fast changes will result in the relocation or extinction of many species. The timing of biological occurrences is changing, which affects species and environments. Insect populations are similarly affected, which disrupts the tritrophic relationships between the plant, its herbivore and natural adversary.

References

Anonymous. (2022). 27th United Nations Climate Change Conference. Dtd. 6-20.11.2022.

Chen F, Ge FandParajulee MN.(2005). Impact of elevated CO_2 on tri-trophic interaction of Gossypiumhirsutum, Aphis gossypii, and Leis axyridis. Environ. Entomol., 34(1): 37-46.

Skendzic S, Zovko M, Zivkovic IP, Lesic VandLemic D. (2021). The impact of climate change on agricultural insect pests. Insects, 12(5): 440.