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Impacts of elevated temperature and CO_2 concentration on plant-insect interaction in subtropical regions

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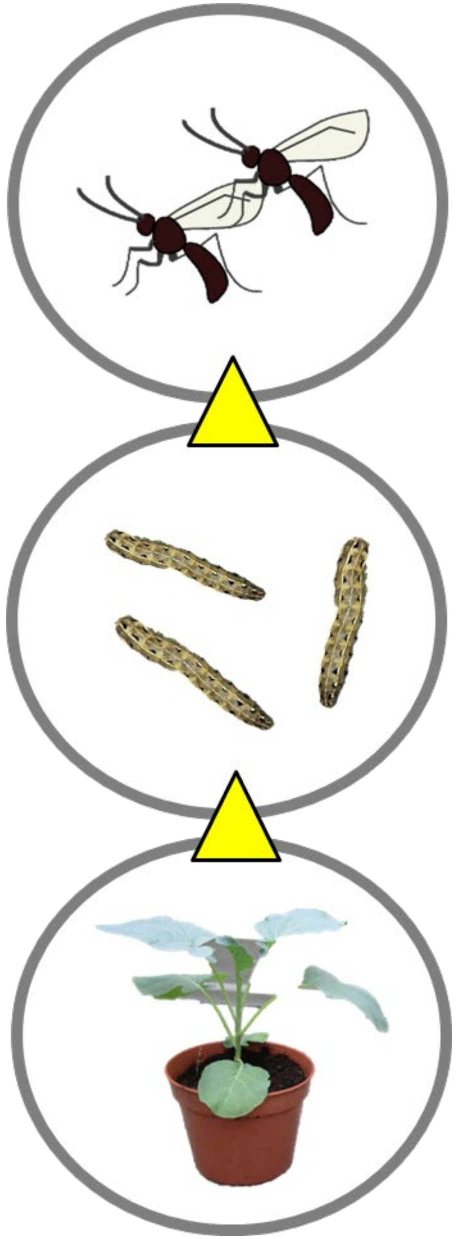


The Effect of Climate Change on Thailand's Agriculture

Climate change impacts on agriculture are expected to significantly affect the economy and the livelihood of the people



Difficulties
- Farmer adaptation
- People awareness

Needs
- Knowledge
- Technology

Lychee production

Orange greening disease

Flooding

Logan production

Insect pest

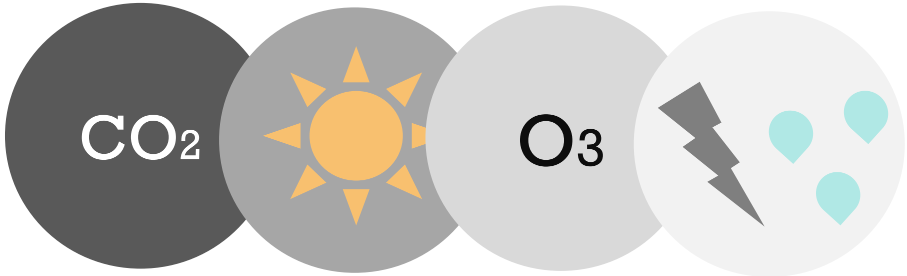
Control methods

- Biological pest control.
- Cultural control.
- Trap cropping.
- Pesticides.

The effects of Climate change

★ A single factor

? Multiple factors

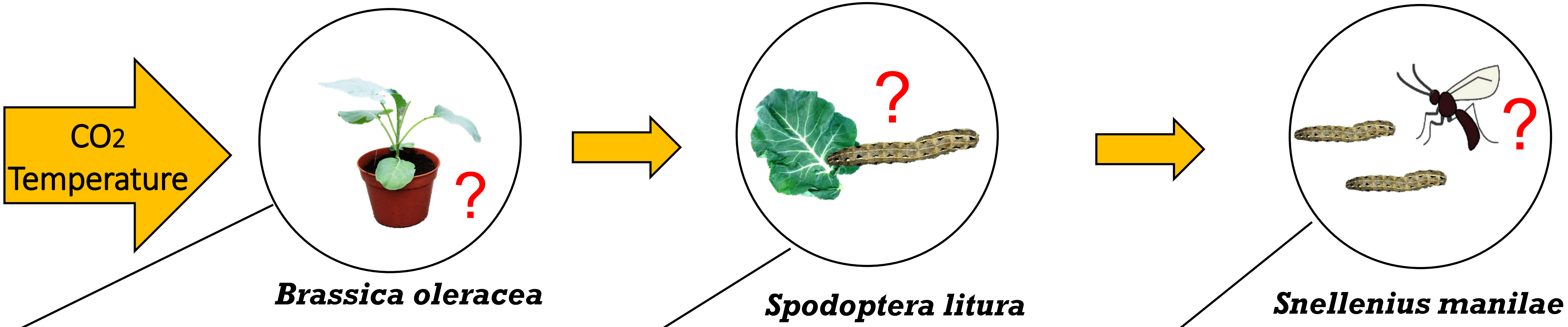


What we know: the effects of climate change on Herbivore

- Promote herbivore outbreaks
- Changes in phenology or distribution
- Insect community

The purpose : To address the consequences of climate change on herbivote performance and the relationship between herbivore and its parasitoid

Questions



- How does elevated CO_2 and temperature affect plant growth?

- How dose herbivore respond?

- How dose parasitoid performance ?

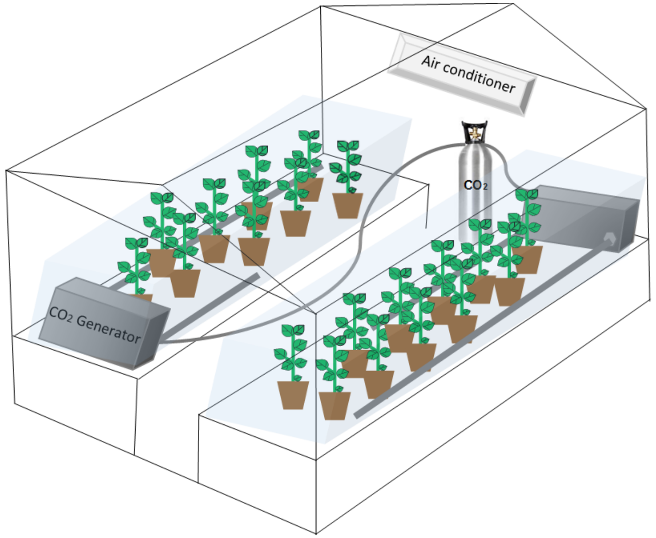
Insect Culture


Spodoptera litura (Fabricius) is a polyphagous insect. It causes serious economic losses on several important crops.


Snellenius manilae (Ashmead) a solitary larval endoparasitoid, and its host range covers only several species of Noctuidae of Lepidoptera; *Spodoptera exigua* (Hübner) and *Spodoptera litura* (Fabricius).

The second instar of *S. litura* is the most suitable host instar, and the suitable growth temperature for *S. manilae* is 25-30℃ (Ting, 2011)

Plant Cultivation Conditions: *Brassica oleracea* L. var. italica.



Greenhouse Conditions

	Elevated CO_2 (1000 ppm)	**Ambient CO_2 (500 ppm)**
Elevated temperature (29/26 °C , day/night)	**Combining**	**High temp.**
Ambient temperature (24/21 °C, day/night)	**High CO_2**	**Control**

***The rising of CO_2 1000 ppm this concentration is expected increase by 2100 and a 5°C warming was based on the IPCC prediction.

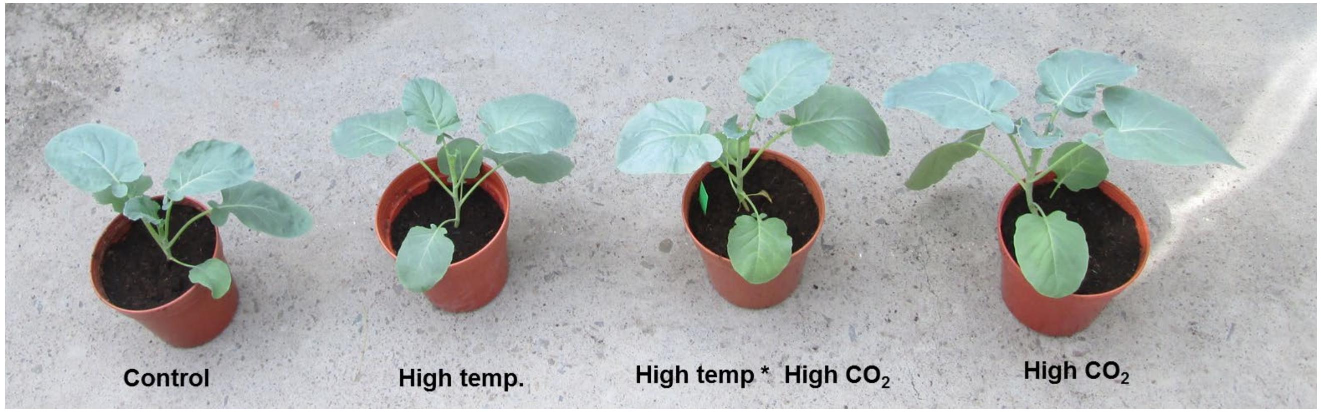
*** The level of industrialization, the CO2 measurements made at Hsinchu industrialized area (Taiwan) showed large amplitude of CO2 concentrations varying between 390 ppm and 470 ppm (Wang, Wang, & Liu, 2014).

***The temperature of 24/21°C represented the ambient temperature
(The average temperature in 2000-2016 November in Taichung, Central Weather Bureau).

Biomass: Dry weight, fresh weight and leaf area

Table 1. Biomass of broccoli plant grown at different temperatures and CO_2 concentrations

Growth environment	Dry weight (g)	Fresh weight (g)	Leaf area (cm^2)
Ambient	0.76±0.063[b]	6.97±0.573[bc]	217±12[c]
High CO_2	1.00±0.071[a]	11.61±0.814[a]	322±18[a]
High temp.	0.54±0.034[c]	6.11±0.400[c]	196±12[c]
High temp * High CO_2	0.92±0.041[a]	8.14±0.411[b]	263±10[b]
P values			
Temperature	0.0089	0.0004	0.0035
CO_2	<.0001	<.0001	<.0001
Temperature*CO_2	0.1931	0.0278	0.1571

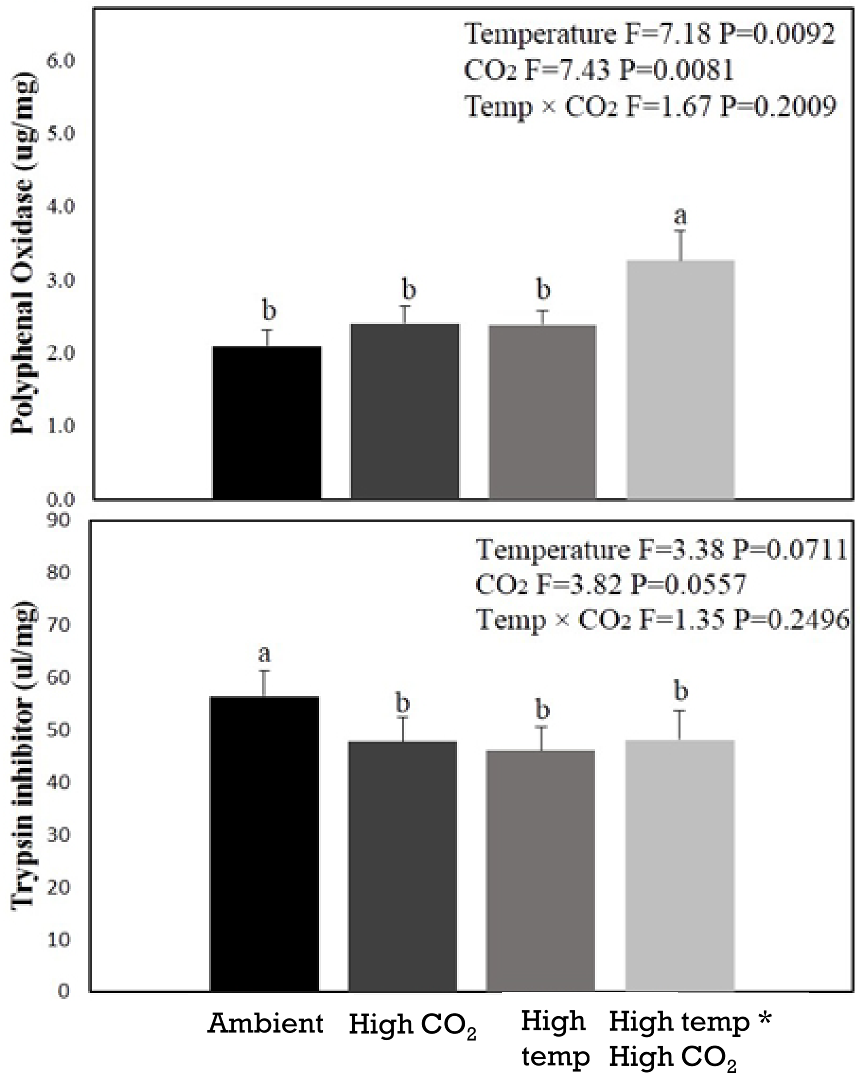


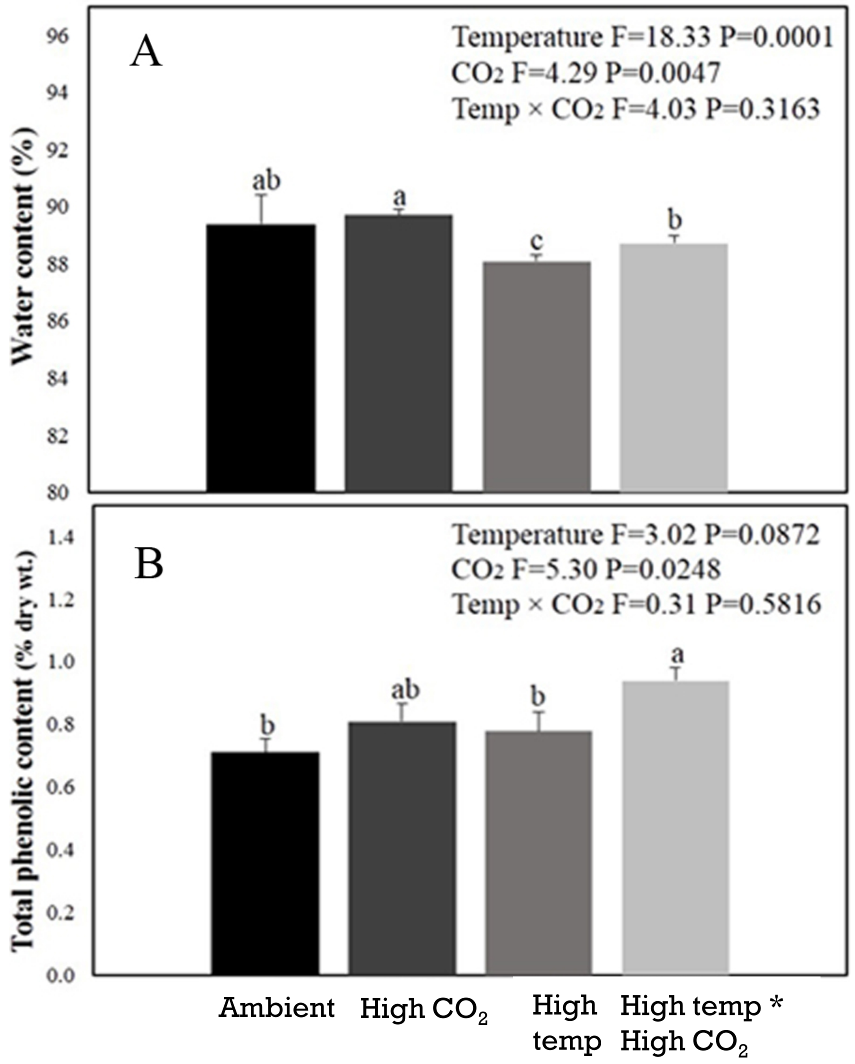
Major foliar chemistry : Nitrogen content, C:N ratio

Table 2. Foliar quality of broccoli plant grown at different temperatures and CO_2 concentrations

Growth environment	Nitrogen content (%)	Total nonstructural carbohydrate (%)	C:N ratio
Ambient	1.574±0.177[b]	21.73±0.38[c]	14.94±1.50[b]
High CO_2	0.835±0.100[c]	31.22±0.62[ab]	30.81±1.8[a]
High temp.	1.978±0.116[a]	26.57±0.39[bc]	18.07±1.7[b]
High temp * High CO_2	1.094±0.221[bc]	35.49±1.11[a]	23.57±0.6[ab]
P values			
Temperature	0.0098	0.1728	0.2724
CO_2	<.0001	0.0008	0.0031
Temperature*CO_2	0.3723	0.1338	0.1931

- Elevated CO2 strongly reduced the nitrogen content and unbalancing the C:N ratio.
- Elevated temperature exerted less of an effect on plant nutrition quality compared with elevated CO_2.


Temperature F=7.18 P=0.0092
CO2 F=7.43 P=0.0081
Temp × CO2 F=1.67 P=0.2009
Polyphenal Oxidase (ug/mg)
6.0
5.0
4.0
3.0
2.0
1.0
0.0
b
b
b
a
Temperature F=3.38 P=0.0711
CO2 F=3.82 P=0.0557
Temp × CO2 F=1.35 P=0.2496
Trypsin inhibitor (ul/mg)
90
80
70
60
50
40
30
20
10
0
a
b
b
b
Ambient
High CO2
High temp
High temp * High CO2


A
Temperature F=18.33 P=0.0001
CO2 F=4.29 P=0.0047
Temp × CO2 F=4.03 P=0.3163
Water content (%)
96
94
92
90
88
86
84
82
80
ab
a
c
b
B
Temperature F=3.02 P=0.0872
CO2 F=5.30 P=0.0248
Temp × CO2 F=0.31 P=0.5816
Total phenolic content (% dry wt.)
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
b
ab
b
a
Ambient
High CO2
High temp
High temp * High CO2

Food utilization of early and mid-instar larval

It is defined as the ability of the insect body to ingest and metabolize food through adequate diet.

Short-term feeding

Insect initial weight, feces and weight gain

RGR: Relative growth rate

RCR: Relative consumption rate

ECI: The efficiency of conversion of ingested food

ECD: The efficiency of conversion of digested food

Spodoptera litura performance

Second-instar

Treatments	RGR (mg/mg/day)	RCR (mg/mg/day)	ECI(%)	ECD (%)
Control	0.084 ± 0.002^{a}	0.659 ± 0.056^{b}	25.46 ± 2.145^{c}	16.69 ± 2.369^{a}
High CO_2	0.064 ± 0.005^{b}	2.028 ± 0.043^{a}	42.50 ± 4.996^{ab}	8.303 ± 1.340^{b}
High temp	0.076 ± 0.005^{ab}	1.206 ± 0.052^{b}	30.62 ± 4.026^{bc}	7.830 ± 1.740^{b}
Combined	0.066 ± 0.005^{b}	2.307 ± 0.058^{a}	52.93 ± 6.847^{a}	6.761 ± 1.393^{b}
F and P value				
Temp	0.17, 0.6815	2.36, 0.1286	4.21, 0.0449	6.28, 0.0149
CO_2	7.86, 0.0067	23.43, 0.0001	18.55, 0.0001	7.06, 0.0101
Temp*CO_2	0.91, 0.3448	0.69, 0.4095	0.027, 0.6075	3.03, 0.0867

- Relative growth rate was reduced and larvae consumed more plant materials that had been exposed to elevated CO_2.

Spodoptera litura performance

Third-instar

Treatments	RGR (mg/mg/day)	RCR (mg/mg/day)	ECI (%)	ECD (%)
Control	0.091±0.002 [a]	0.670±0.235[b]	29.44±5.190[ab]	15.58±2.236[a]
High CO_2	0.085±0.004 [a]	1.269±0.459 [a]	14.08±3.162[b]	14.10±2.126[a]
High temp	0.085±0.002 [a]	0.727±0.181[b]	30.02±3.316[ab]	10.41±1.025[a]
Combined	0.086±0.002 [a]	1.191±0.108[ab]	34.33±3.572[a]	16.54±3.257[a]
F and P value				
Temp	0.54, 0.4674	1.10, 0.3034	0.48, 0.4933	0.25, 0.6217
CO_2	0.53, 0.4710	5.11, 0.0320	0.40, 0.0529	0.11, 0.7398
Temp*CO_2	0.99, 0.3252	0.62, 0.4393	2.17, 0.1492	0.79, 0.3819

- Larvae consumed more plant materials that had been exposed to elevated CO_2.

Spodoptera litura performance

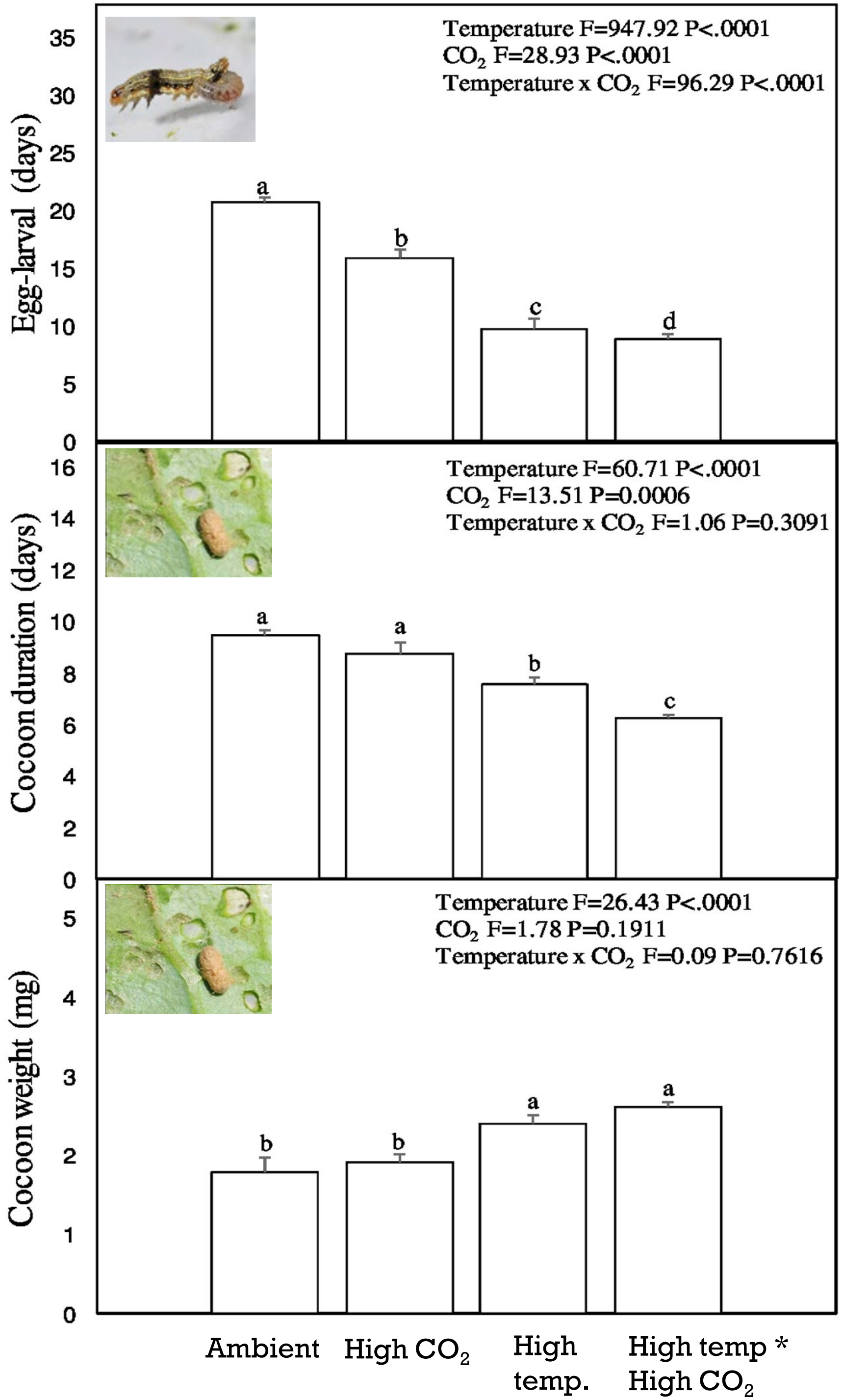
Fourth instar

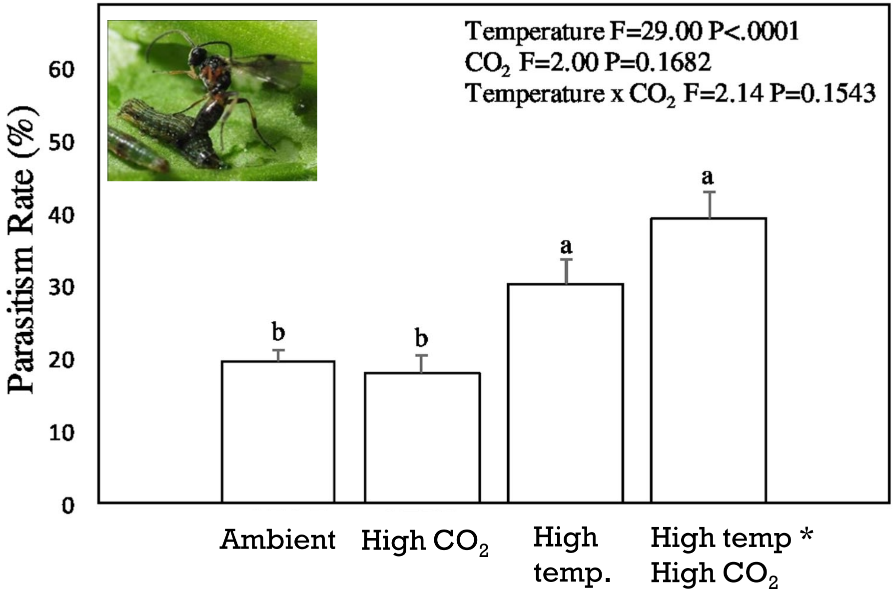
Treatments	RGR (mg/mg/day)	RCR (mg/mg/day)	ECI(%)	ECD (%)
Control	0.080±0.010 [a]	0.181±0.047[c]	13.30±4.145[a]	46.73±2.369[a]
High CO_2	0.086±0.001 [a]	0.312±0.036 [ab]	10.99±2.130[a]	28.61±1.340[a]
High temp	0.081±0.004 [a]	0.231±0.035[c]	9.716±2.085[a]	56.08±1.740[a]
Combined	0.088±0.002 [a]	0.449±0.030[a]	17.06±2.098[a]	26.04±2.534[a]
F and P value				
Temp	0.06, 0.803	2.11, 0.1567	0.45, 0.507	0.05, 0.8314
CO_2	1.08, 0.3067	8.51, 0.0066	0.98, 0.3292	6.62, 0.0197
Temp*CO_2	0.02, 0.8798	1.11, 0.2999	3.47, 0.0727	0.46, 0.5051

- The food utilization efficiencies of 2nd instar larvae were more sensitive to CO_2-treated foliage than those of the 3rd and 4th instar larvae.
- The various larval stages might respond differently to climate change.

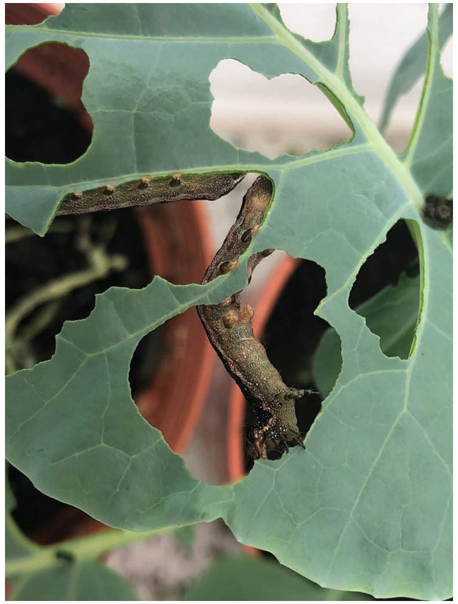
Snellenius manila performance

40 of 2[nd] larvae / 1 female parasitoid

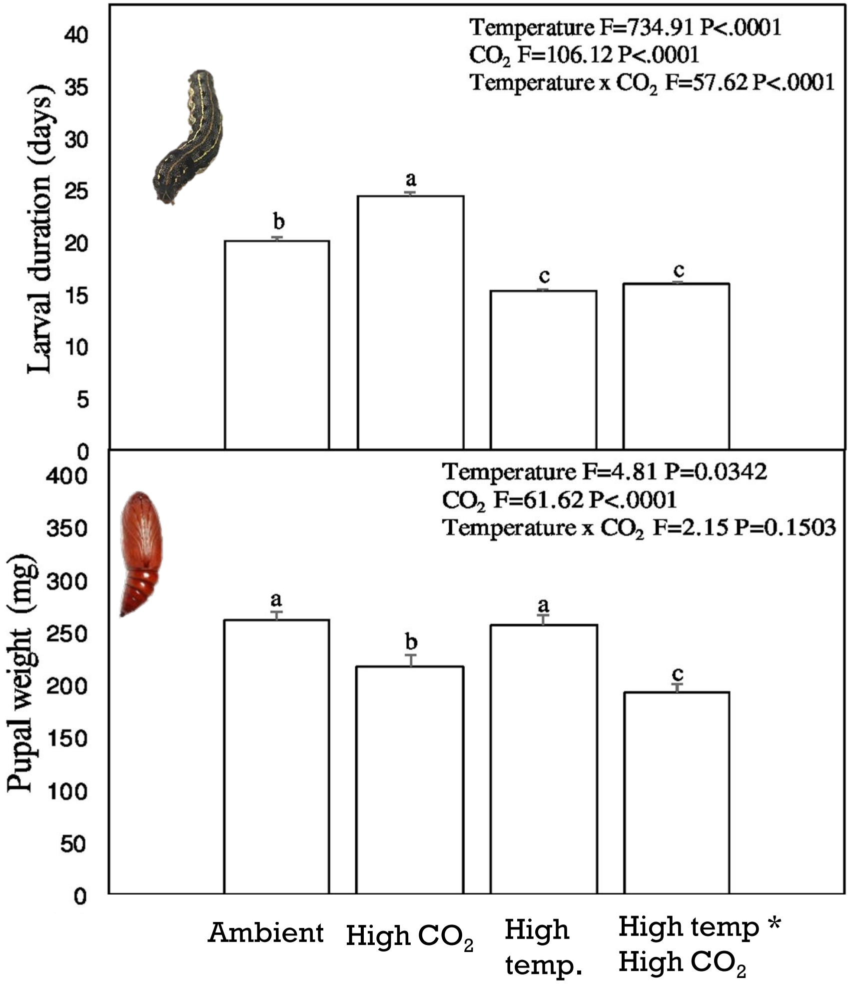




The adaptability ?

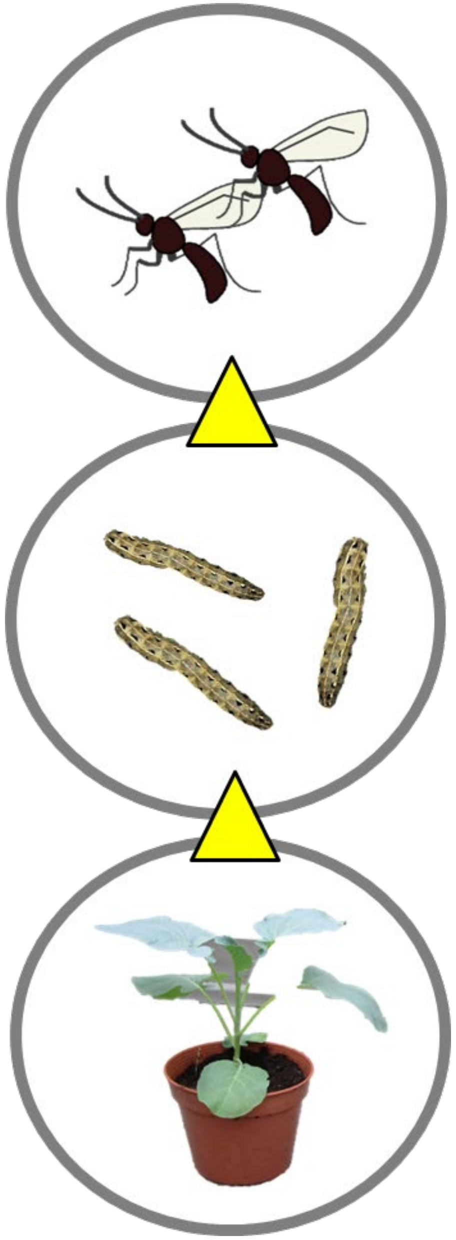


The long term development?



10 larvae / 1cage

Conclusion



A changes plant nutrition's and defensive compounds can affect the performance of herbivorous and it parasitoid.

The phenology tri-trophic interactions data will be particularly useful in improving our ability to predict ecosystem-level changes to climate change.

Large-scale and long-term experiments, which will be especially important in terms of making realistic predictions about community responses.

Interesting finding

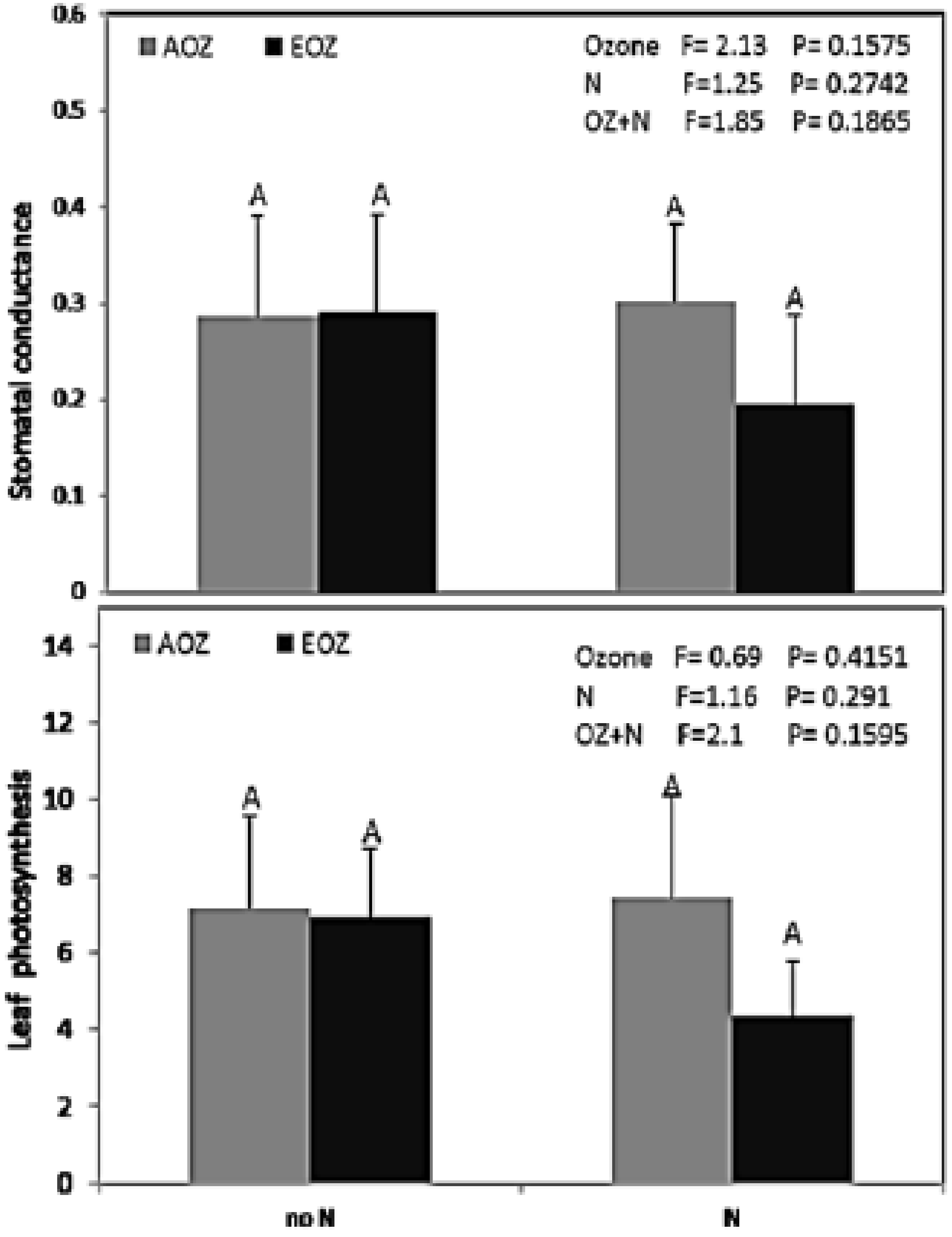
The potential of using black soldier fly (BSF) compost as a bio-fertilizer under elevated CO2

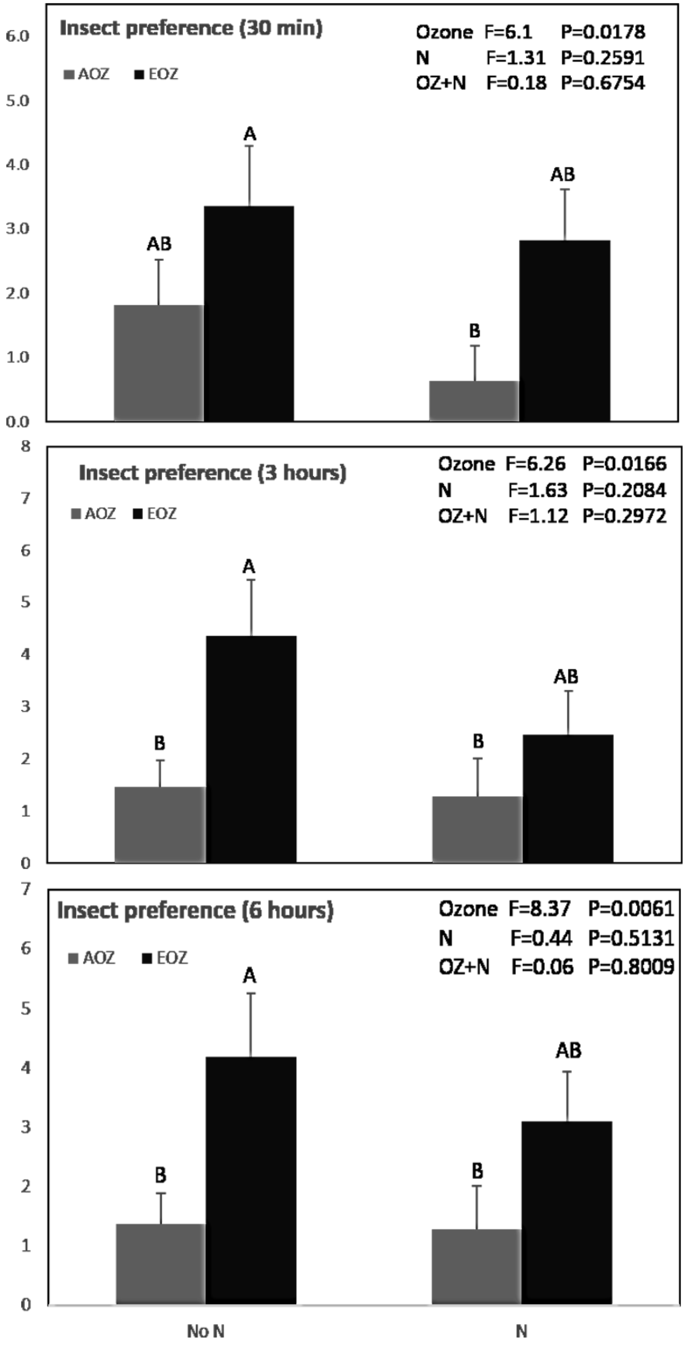
Hermetia illucens (Black soldier fly)

Impact of ozone and nitrogen deposition on tomato performance and chemical defenses subsequently on insect preference

Solanum lycopersicum

Free-air O3 enrichment system (FACE).
The elevated O_3 plots 13 was 70±7 nmol mol^{-1},the ambient plots were subjected to daytime O_3 concentration of 30±4 nmol mol^{-1}. The doses of fertilizer applied 80 kg/ha.


AOZ
EOZ
Ozone F= 2.13 P= 0.1575
N F=1.25 P= 0.2742
OZ+N F=1.85 P= 0.1865
Stomatal conductance
0.6
0.5
0.4
0.3
0.2
0.1
0
A
A
A
A
AOZ
EOZ
Ozone F= 0.69 P= 0.4151
N F=1.16 P= 0.291
OZ+N F=2.1 P= 0.1595
Leaf photosynthesis
14
12
10
8
6
4
2
0
A
A
A
A
no N
N


Insect preference (30 min)
AOZ
EOZ
Ozone F=6.1 P=0.0178
N F=1.31 P=0.2591
OZ+N F=0.18 P=0.6754
6.0
5.0
4.0
3.0
2.0
1.0
0.0
AB
A
B
AB
Insect preference (3 hours)
AOZ
EOZ
Ozone F=6.26 P=0.0166
N F=1.63 P=0.2084
OZ+N F=1.12 P=0.2972
8
7
6
5
4
3
2
1
0
B
A
B
AB
Insect preference (6 hours)
AOZ
EOZ
Ozone F=8.37 P=0.0061
N F=0.44 P=0.5131
OZ+N F=0.06 P=0.8009
7
6
5
4
3
2
1
0
B
A
B
AB
No N
N

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Thank you