SHORT-TERM CONTROLLED ATMOSPHERE TREATMENTS FOR CONTROL OF APHIDS AND THRIPS: EFFICACY AND TOLERANCE BY CUT FLOWERS AND LEAFY VEGETABLES

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A range of quarantine insects are found on leafy vegetables and cut flowers. We have focused on the possible use of short-term controlled atmosphere treatments for disinfestation of these commodities, using the most common insects, thrips and aphids as our model. Initial experiments indicated that relatively brief exposures (a few days to 1 week) to CO_2-enriched atmospheres (10-30%) were effective in killing adult thrips and aphids with minimal phytotoxicity at low temperatures (**Table 1**). Low oxygen in combination with 10% CO_2 was effective in achieving 100% mortality of thrips by 7 days, but required >14 days for complete aphid kill at these low temperatures.

Exposure of thrips and aphids to 60% CO_2 in air showed that increasing the temperature from 0C (32F) to 20C (68F) increased insect kill (**Table 2**). At lower temperatures, aphids were killed more easily than thrips, whereas at 20C (68F) there were no differences in mortality.

We have extended these interesting findings by examining the response of insects and commodities over a wider range of CO_2 concentrations and temperatures. The response surface for adult Western flower thrips *(Frankliniella occidentalis)* indicate that there is an increase in the insecticidal activity of CO_2 with increasing temperature (**Tables 3 and 4**). We found that relatively short exposures to very high CO_2 concentrations (80 - 100% CO2) resulted in complete kill of adult thrips even at the low temperatures. We tested the tolerance of a range of commodities (fruits, flowers and vegetables) to these atmospheres and found them to be surprisingly tolerant of short exposures (4-24 hr) to these high concentrations of CO_2 even at elevated temperatures (48C (118F) was not tested). Our preliminary assessments of product tolerance were based primarily on visual quality, discoloration and off-odors, evaluated after treatment plus a 1 week storage period.

We also studied the susceptibility of other life stages of thrips, and found that second instar larvae were considerably more tolerant than adults to the high CO_2 atmospheres tested (**Table 5**), and pupae were more tolerant yet (data not shown). This preliminary experiment consisted of only a 1 hour exposure and it was possible to reach high levels of mortality at very high temperatures. Longer exposures at intermediate and lower temperatures may result in adequate mortality of these more resistant stages.

Reference:
Zheng, J.M., M.S. Reid, D.Y. Ke and M.I. Cantwell. 1993. Atmosphere modification for postharvest control of adult thrips and aphids on flowers and green leafy vegetables. Proc. 6th Intl. Controlled Atmosphere Conference. NRAES-71, pp.394-401.

Table 1. Comparison of insect and commodity tolerances to controlled atmospheres at 0 or 5C (32 or 41F).

Temperatures and Atmospheres	Days for 100% Mortality[1]		Commodity Tolerance (days)[2]			
	Aphids	Thrips	Rose	Carnation	Broccoli	Lettuce
0C Air	>21	>21	>21		>21	>21
2% O2	>21	>21	>21		>21	>21
0.5% O2	>21	21	>21		>21	21
0.02% O2	7-14	14-21	15-20		9	13
5C Air	>21	21	>21	>21	21	17
2% O2	14-21	14-21	>21	>21	>21	>21
0.5% O2	14-21	14-21	>21		>21	>21
0.02% O2	7	7-14	7-14		4	11
0C Air	>6	>6	>14	>14	>14	>6
10% CO2	>6	6	>14	>14	>14	6
30% CO2	4	4	4	6	2	5
50% CO2	4	4	2	6	2	5
5C Air	>6	>6	>6	>6	>6	>6
10% CO2	6	>6	>6	>6	>6	5
30% CO2	6	4	2	6	2	4
50% CO2	6	4	1	6	2	3
0C Air	>14	>14	>14	>14	>14	>14
2% O2 + 10% CO2	>14	7	>14	>14	>14	6
1% O2 + 10% CO2	>14	7	>14	>14	>14	6
0.5% O2 + 10% CO2	>14	7	>14	>14	>14	6
5C Air	>14	>14	>14	>14	>14	5
2% O2 + 10% CO2	>14	14	>14	>14	>14	5
1% O2 + 10% CO2	>14	7	>14	>14	>14	5
0.5% O2 + 10% CO2	>14	7	>14	>14	>14	5

[1]Data were obtained with non-feeding insects. It took more time to completely kill feeding thrips, but not feeding aphids.

[2]Commodity tolerance was the number of days until slight injury and/or slight off-odor occurred, or visual quality decreased to fair. The roses were red, carnations were pink and white, and iceberg lettuce was used.

Table 2. Mortality of aphids and thrips (*Frankliniella occidentalis*) with short-term exposure to 60% CO2 in air at 0C (32F), 10C(50F) and 20C (68F). Data are from 3 experiments, and are calculated from 60 insects per treatment per experiment.

Exposure	% Mortality					
	Aphids			Thrips		
	0C (32F)	10C (50F)	20C (68F)	0C (32F)	10C (50F)	20C (68F)
24 hr	86	95	89	46	30	89
36	97	99	100	67	47	100
48	97	100	100	75	78	100
60	99	100	100	88	93	100
Air, 60 hr	17	22	13	9	8	13

Table 3. Mortality of adult thrips exposed to different controlled atmospheres for *4 to 8 hours* at various temperatures. After treatment, insects were transferred several hours to air at 20C)68F) before assessment of mortality. Data are means of four experiments, two for the 4 hour exposure and two for the 8 hour exposure; Data are means of results for ~90-120 insects per treatment.

	% Mortality					
	0C	12C	24C	30C	36C	48C
Atmospheres/Temperature	32F	55F	75F	86F	97F	118F
1. Air	50	48	46	29	66	98
2. Carbon Dioxide (100%)	100	100	100	86	100	100
3. Nitrogen (100%)	86	65	80	95	100	100
4. 40% CO2 in N2	98	90	100	99	92	100
5. 40% CO2 in 0.25% O2	100	90	84	88	97	100
6. 40% CO2 in 2% O2	81	80	80	92	100	100
7. 40% CO2 in 12% O2	62	62	58	66	71	100
8. 60% CO2 in N2	81	91	100	100	100	100
9. 60% CO2 in 0.25% O2	78	62	69	70	62	100
10. 60% CO2 in 2% O2	92	92	100	100	100	100
11. 60% CO2 on 8% O2	87	80	93	99	83	100
12. 80% CO2 in N2	100	68	78	75	85	100
13. 80% CO2 in 0.25% O2	100	100	100	75	85	100
14. 80% CO2 in 2% O2	100	100	100	100	100	100
15. 80% CO2 in 4% O2	100	100	100	100	100	100

Table 4. Mortality of adult thrips exposed to different controlled atmospheres for *24 hours* at various temperatures. After treatment, insects were transferred several hours to air at 20C (68F) before assessment of mortality. Data are means of results for ~50-60 insects per treatment.

	% Mortality					
	0C	12C	24C	30C	36C	48C
Atmospheres/Temperature	32F	55F	75F	86F	97F	118F
1. Air	30	66	11	53	88	98
2. Carbon Dioxide (100%)	100	100	100	100	100	100
3. Nitrogen (100%)	66	50	89	100	100	100
4. 40% CO2 in N2	100	96	100	100	100	100
5. 40% CO2 in 0.25% O2	100	96	100	100	100	100
6. 40% CO2 in 2% O2	96	100	100	100	100	100
7. 40% CO2 in 12% O2	68	96	69	64	86	100
8. 60% CO2 in N2	97	100	100	100	100	100
9. 60% CO2 in 0.25% O2	62	83	60	78	100	100
10. 60% CO2 in 2% O2	100	100	100	100	100	100
11. 60% CO2 on 8% O2	100	100	100	100	100	100
12. 80% CO2 in N2	66	56	68	89	100	100
13. 80% CO2 in 0.25% O2	92	100	100	100	100	100
14. 80% CO2 in 2% O2	66	100	100	100	100	100
15. 80% CO2 in 4% O2	100	100	100	100	100	100

Table 5. Mortality of Western flower thrips exposed to different controlled atmospheres for *1 hour* at various temperatures. After treatment, insects were transferred several hours to air at 20C (68F) before assessment of mortality. Data are from one experiment for instar II (I) and from two experiments for adult (A) thrips.

	% Mortality											
	0C		12C		24C		30C		36C		48C	
Atmospheres/Temperature	32F		55F		75F		86F		97F		118F	
	A	I	A	I	A	I	A	I	A	I	A	I
1. Air	37	0	70	0	28	0	51	7	82	0	85	100
2. Carbon Dioxide (100%)	100	50	100	75	100	40	90	0	94	78	100	75
3. Nitrogen (100%)	50	25	81	0	72	25	56	50	34	71	100	42
4. 40% CO2 in N2	85	0	100	0	95	20	100	22	100	13	100	92
5. 40% CO2 in 0.25% O2	100	0	100	6	100	5	97	0	100	0	100	93
6. 40% CO2 in 2% O2	100	10	100	28	100	25	100	14	100	50	100	95
7. 40% CO2 in 12% O2	66	11	76	0	94	12	68	100	40	50	97	100
8. 60% CO2 in N2	100	--	94	--	100	--	100	--	100	--	100	--
9. 60% CO2 in 0.25% O2	80	9	80	81	88	0	75	0	82	0	100	0
10. 60% CO2 in 2% O2	100	--	100	--	100	--	100	--	100	--	100	--
11. 60% CO2 on 8% O2	84	0	100	--	61	6	96	50	94	50	100	94
12. 80% CO2 in N2	100	23	93	3	100	25	100	50	100	--	100	100
13. 80% CO2 in 0.25% O2	100	6	100	23	100	47	100	33	100	--	100	95
14. 80% CO2 in 2% O2	96	--	82	--	100	--	100	--	100	--	100	--
15. 80% CO2 in 4% O2	100	50	100	22	94	12	100	28	100	75	100	100