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Evaluation of Modified Atmospheres as a Potential Disinfestation Technique for Thrips and Mites in Greenhouses

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BACKGROUND

Arthropod pests can enter a greenhouse either on an unrestricted airflow or on infested plant material. Thus, pest infestations originating on propagules may inadvertently be spread to other greenhouses. Control tactics that target pests on propagules, could be valuable in reducing further distribution. Most growers use insecticides to manage arthropod pests, but this option has become restricted because of environmental, worker, and consumer safety issues. Modified atmospheres created with CO_2 or N_2 have been used to control arthropods on fruits and vegetables. However, the need for prolonged exposure to low temperatures prevents the application of this technology to actively growing plants. We propose that modified atmospheres could potentially be used to eliminate greenhouse pests by treating plant propagules before, during, or immediately after shipment.

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MATERIALS AND METHODS

System construction. A prototype system of 12 treatment chambers was developed with 10-liter vacuum dessicators. Test gases were used at 100% for all trials. All experiments were conducted at 20°C.

Species tested. Adults of Western flower thrips, twospotted spider mites, sweetpotato whiteflies, green peach aphids and larval fungus gnats were used for one or more tests. Mites and thrips were confined on a bean leaf disc on moistened absorbent cotton within a plastic Petri dish with a screened lid. Fungus gnat larvae were tested on potato slices also in a screened Petri dishes. Whiteflies and aphids were confined to a fresh mum cutting inside a screened plastic cylinder.

Comparative thresholds for greenhouse pests. We evaluated the susceptibility of the five aforementioned major greenhouse pests and determined the minimum time required to control the pest with either CO_2 or N_2. Both CO_2 and N_2 were tested against air, using exposure times of 6, 12, and 18 h.

Susceptibility of twospotted spider mite eggs versus adults. In all tests, a single life stage was prepared on a leaf disc as previously described. We first compared the survival of adults and eggs exposed for 24 h to either CO_2 vs. air or N_2 vs. air. Next, adult and eggs survival was compared following exposure to N_2 for 12 and 24 h. Finally, survival of adults and eggs was determined after exposure to either air, CO_2, or N_2 for 12h.

Compatibility of modified atmosphere treatments with plant species and cultivars.
We also studied whether or not the conditions that are required to kill pests would adversely affect commonly grown greenhouse plants. Cocktail series begonia seedlings were exposed for 6, 12, or 24 h to either N_2 or air atmospheres. A second experiment was conducted by exposing different sets of seedlings to either air, N_2, or CO_2 for 6 or 18 h. We also tested the compatibility of rooted cuttings of different cultivars of geranium (Melody Red and Everglow) and chrysanthemum (Pomona, Charm, and Red Remarkable) exposed to either air, N_2, or CO_2 for 12 h. Following exposure, the plants were rated for aesthetic quality.
A study of the chronic effects of exposure was conducted with Super Elfin impatiens seedlings. Plants were exposed to 6- and 12-h exposures of either N_2 or air. After treatment, plants were transplanted and grown in the greenhouse for 4 wks. Flowering and vegetative characters for each plant were evaluated during that period.
Effect of the presence of plants on pest survival.
Since growers would treat living plants, we hypothesized that O_2 production from plants might increase pest survival. We tested the effect of living plants, and light or dark, on survival of adult mites and thrips. In this test, half of the treatment chambers were wrapped completely with aluminum foil. Across both light treatments, half of the chambers received 40 impatiens seedlings each while the others were without plants. Thrips and mites were exposed separately inside each chamber to N_2 for 12 h.

CONCLUSIONS
In the first experiment, no insect species survived 18 h exposure to either CO_2 or N_2 except fungus gnat larvae which had survival < 42% in all treatments including air controls. No whiteflies survived 6-h exposures to either gas. Aphid survival was 28 and 20% for CO_2 and N_2, respectively, at 6-h and 0% thereafter. No mites survived 12 h of exposure to CO_2, whereas survival in N_2 for the same exposure time was 20%. For thrips, survival after 12 h was 4.2 and 10% for CO_2 and N_2 respectively, and 0% thereafter for both.
In all trials with mite eggs and adults, exposures that were lethal to adults also killed eggs.
Tolerance of begonias varied between trials. For example, in one trial, all plants exposed to N_2 for 12 or 24 h were killed. In another trial, N_2 exposures as long as 18 h caused no damage. However, both 6- and 18-h exposures to CO_2 caused significant damage. When exposed for 12 h, all mum and geranium cultivars has significantly more damage from CO_2 than from N_2 exposure. Aesthetic quality of N_2-treated plants was not different from control plants.
In the Impatiens experiment, vegetative characteristics were unaffected by treatment. Plants exposed to N_2 for 12 h required 4 days longer to flower than controls, and only 58% of plants flowered in 4 wks.
In the light experiment, survival of mites or thrips under N_2 treatment was significantly higher in the presence of plants.
IMPACT TO THE INDUSTRY
(1) This study indicates that it may be feasible to use short-term, modified atmosphere treatments at moderate temperatures to control greenhouse pests on propagules before, during, or after shipment. (2) The studies also indicate that pests, and especially plants, can vary in their tolerance of hypoxic conditions. Interactions between treatment variables such as treatment gas, O_2 concentration, or relative humidity and the plants and pests being treated may modify the effectiveness of modified atmospheres. (3) Greater understanding of these interactions are necessary before this technology can be implemented to control pests on the diverse plant species and cultivars being produced in commercial greenhouses.