CONTROLLED ATMOSPHERE TREATMENTS FOR POSTHARVEST CONTROL OF TWO SPOTTED SPIDER MITES *(Tetranychus urticae)*

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Two spotted spider mite, *Tetranychus urificae,* is a pest on many California fruit crops such as strawberries, pears, and stone fruits and on many cut flowers. Control of two spotted spider mites is essential for strawberries shipped to Japan and may become important for pears, stone fruits and cut flowers shipped to various markets. The effect of controlled atmosphere treatment, a potential alternative to methyl bromide fumigation, on the mortality of this arthropod was investigated.

The effects of 4 high CO_2 atmospheres, 50, 65, 80, and 95% CO_2 in air at 0°C Were tested. The insecticidal efficacy of CO_2 increased with concentration. With 50% CO_2, the LT_{99s} for adults, protonymphs, and larvae were 11. 9, 9.9, and 7.5 d, respectively; with 65% CO_2, 9.2, 8.8, and 7.4 d, respectively, with 80% CO_2, 7.3, 7.3, and 6.4 d, respectively, and with 95% CO_2, 5.4, 5.5, and 4.6 d respectively. The larval stage was easier to kill than the adult and protonymphal stages.

Since 95% CO_2 in air (1% O_2) at O°C was the most effective treatment, we further tested the effects of combinations of 95% CO_2 with various low O_2 concentrations--0, 0. 1, and 0.5% O_2 (balance N_2). Lowering the O_2 concentration did not increase the efficacy of 95% CO_2 treatment at O°C. There was no synergistic effect between 95% CO_2 and ultra low O_2 or pure N_2 at O°C. The insecticidal efficacy of 0% O_2 alone at 0°C was also tested. At 2 and 4 d, 0% O_2 caused only 12-26% mortality, which was not significantly different from that of treatment in air at 0°C ($P<0.05$). At 6 d, 0% O_2 began to have an insecticidal effect, resulting in about 55% mortality for adults and protonymphs and above 99% mortality for larvae. The insecticidal efficacy of 0% O2 at 0°C for 6 d was equivalent to that of 50% CO_2. Use of ultra low O_2 treatments at 0°C do not appear promising for control of two spotted spider mite, while high CO_2 treatments are more promising.

Since we had previously found that sequential controlled atmosphere treatments were effective against Pacific spider mites, we tested the effects of sequential controlled atmosphere treatments on two spotted spider mites. A shock treatment with 0, 0.125, or 0.25% O_2 or 95% CO_2 in air at 20°C for 0.5 and 1 d was followed by 18 d of cold treatment in air at O°C. Shock treatments alone at 20°C for 0.5 d resulted in about 40% mortality. No significant difference in mortality was observed among the 4 shock atmospheres. The efficacy of ultra low O_2 treatments was much greater at 20°C than at O°C. A 6 d treatment with 0% O_2 at O°C resulted in 55% mortality, while only 1 d of treatment with 0% O_2 at 20°C resulted in 99% mortality.

When the shock treatments were followed by 18 d of 0°C air, arthropod mortality increased greatly. When followed by 18 d 0°C air, shock treatment with 0% O_2 at 20°C for 0.5 d resulted in greater than 96% mortality for adults and protonymphs; treatment with 0. 125% O_2 resulted in 90% mortality; treatment with 0.25% O_2 resulted in 76% mortality; and treatment with 95% CO_2 resulted in greater than 96% mortality. When 1 d shock treatments with 0% O_2, 0.125% O_2 or 95% CO_2 at 20°C were followed by 18 d of 0°C air, 100% mortality was obtained for all lifestages. Preliminary data also showed that when an 18 d mild controlled atmosphere (8% CO_2) treatment, instead of cold air, was combined with the shock treatments, the insecticidal efficacy of the combination treatment increased.

The most promising treatments include a 5.5 d treatment with 95% CO_2 in air at 0°C, and a 1 d shock treatment with 95% CO_2 or 0.125% O_2 at 20°C followed by 18 d of 0°C air. Product tolerance to 5.5 d at 95% CO_2 may be a challenge to adoption of this treatment. Product tolerance to the sequential treatments appears promising, but must be thoroughly tested. These treatments could be implemented prior to shipment or during marine transit. For strawberries, controlled atmosphere treatment alone does not hold much promise unless strawberries could be stored nearly three weeks under elevated CO_2 atmospheres. Pears, stone fruits and cut flowers would likely tolerate such treatment; however, thorough testing of product tolerance is necessary.