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Are low humidity levels a limiting factor for spider mite control by phytoseiid predators under fluctuating climatic conditions?

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Abstract: Low humidity levels are assumed to be an important limiting factor for biological control of spider mites by phytoseiid predatory mites, mainly because of the vulnerability of the egg stage for drought. In this study, we evaluated the efficacy of several species of phythoseiid predatory mites for control of the spider mite *Tetranychus urticae* Koch at low (55%) and high (80%) humidity levels on greenhouse cucumber in two greenhouse trials where predators were released either before or after spider mite introductions. In the preventive trial, the best control was achieved by *Neoseiulus californicus* McGregor at both humidity levels. Spider mites were completely eradicated. None of the other species of predatory mites was able to reduce spider mite densities, except *Transeius montdorensis* (Schicha) at the low humidity level. In the curative trial, *N. californicus* was again the best performing predatory mite, together with *Phytoseiulus persimilis* Athias-Henriot. Spider mites were completely controlled at both humidity levels by these species. This suggests that low humidity levels during daytime do not necessarily disrupt the control of spider mites by these predators, possibly because of the humidity fluctuations between day and night. Humidity did also directly affect spider mites; densities were up to 3 times higher on plants in the greenhouse with low humidity levels than on plants with a high humidity level. This increased growth rate of spider mites at low humidity levels may be another explanation for the failure of spider mite control in practice. Yet, in order to enhance the biological control of spider mites at low humidity levels, it might be better to focus on methods that support the establishment of effective spider mite predators, rather than selecting drought adapted strains of predatory mites.

Key words: *Phytoseiulus persimilis, Neoseiulus californicus, Tetranychus urticae*, greenhouses, cucumber, biological control

Summary: Low humidity levels are assumed to be an important limiting factor for biological control of spider mites by phytoseiid predatory mites, mainly because of the vulnerability of the egg stage for drought (Ferrero et al., 2010; Walzer et al., 2007). Particularly the widely used spider mite specialists *Phytoseiulus persimilis* Athias-Henriot and *Neoseiulus californicus* McGregor (Acari: Phytoseiidae) are very sensitive to dry conditions; lethal humidity levels at which 50% of the eggs die (LH50) range for these species between 66 and 70% (Ferrero et al., 2010; Walzer et al., 2007). These values suggest that arid conditions can soon cause high mortality rates in predatory mite populations. Dutch cucumbers growers indeed report that spider mite control often fails in spring when eastern wind brings dry air. However, whether low humidity levels are really the most important factor for causing unsuccessful spider mite control remains unclear. A recent laboratory study showed that the negative effects of low humidity levels can soon be compensated by short periods of high humidity levels (Le Hesran et al., 2019). Moreover, the humidity levels near the leaf layer might be much higher that the levels measured in the greenhouse. In our study, we evaluated the efficacy of several species of

phytoseiid predatory mites for control of the spider mite *Tetranychus urticae* Koch at low and high humidity levels on greenhouse cucumber in two greenhouse trials where predators were released either before or after spider mite introductions. Spider mite control was evaluated on individual cucumber plants in each trial in two greenhouse compartments of 24 m^2. Humidity levels during the night were always a bit higher in the low humidity treatments and humidity levels during the day were a bit lower for the high humidity treatment. The levels we achieved in the preventive trial were 57% (range 45-74) and 79% (range 70-89). In the second curative trial we achieved average humidity levels of 55% (range 35-76) and 78% (range 52-78). In the preventive trial, the best control was achieved by *N. californicus* at both humidity levels. Spider mites were completely eradicated. None of the other species of predatory mites [*Amblyseius swirskii* Athias-Henriot*, Iphiseius degenerans* (Berlese)*, Euseius gallicus* Kreiter and Tixier, and *Euseius ovalis* (Evans) (Acari: Phytoseiidae)] was able to reduce spider mite densities, except *Transeius montdorensis* (Schicha) at the low humidity level. In the curative trial, *N. californicus* was again the best performing predatory mite, together with *P. persimilis*. Spider mites were completely controlled at both humidity levels by these species. At the low humidity level, none of the other predatory mites (*T. montdorensis, Amblyseius andersoni* and *Neoseiulus fallacis*) was able to reduce spider mite densities, however, at high relative humidity, *T. montdorensis* and *A. andersoni* gave a significant reduction of spider mite densities compared to the treatment without predators. The excellent results with *N. californicus* and *P. persimilis* show that the low humidity levels during daytime do not necessarily disrupt the control of spider mites by these predators, possibly because of the humidity fluctuations between day and night. Another aspect that affects spider mite control is the direct effect of humidity on the growth rate of spider mites. Our study confirmed previous observations that spider mites develop faster at low than high humidity levels (Boudreaux, 1958). Spider mite densities in our study were up to 3 times higher on plants in the greenhouse with low humidity levels than on plants with a high humidity level. This increased growth rate of spider mites at low humidity levels may also explain why in the curative trial *T. montdorensis* and *A. andersoni* were only effective at the high humidity level. Yet, in order to enhance the biological control of spider mites at low humidity levels, it might be better to focus on methods that support the establishment of effective spider mite predators, rather than selecting drought adapted strains of predatory mites.

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