Tomato Russet Mite, Aculops lycopersici (Massee)1, Abundance and Effect on Tomato Yield

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Tomato Russet Mite, *Aculops lycopersici* (Massee)[1], Abundance and Effect on Tomato Yield

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Abstract. *Aculops lycopersici* (Massee) causes plant desiccation and severe damage to tomato (*Lycopersicon esculentum* Mill) fruit, resulting in serious economic loss. The objective of the study was to determine the incidence of damage to fruit by *A. lycopersici*. Three varieties of tomato (SUN 7705, CID, and V305 F1) were used. Variety V305 F_1 had the greatest index of damaged fruit (1.6852a), lowest index of useful fruit, (2.1878a) and least average weight per fruit (302.97a) of the three varieties. CID was least affected. The middle stratum had the greatest index of damaged fruit (2.3070a), lowest index of useful fruit, (1.5660b), and least average weight per fruit (254.89b) of the three strata. The lower stratum was least affected.

Resumen. *Aculops lycopersici* (Massee) provoca la desecación de las plantas y daños graves a los frutos del tomate (*Lycopersicon esculentum* Mill), lo que genera graves pérdidas económicas. El objetivo de este estudio fue determinar la incidencia de daño a frutos por *A. lycopersici*. Se utilizaron tres variedades de tomates (SUN 7705, CID, y V305 F1). De las tres variedades, la variedad V305 F1 presentó el mayor índice de frutos dañados (1.6852a), el menor índice de frutos útiles (2.1878a), y el menor peso promedio por fruto (302.97a). La variedad CID fue la menos afectada. De los tres estratos, el estrato medio presentó el mayor índice de frutos dañados (2.3070a), el menor índice de frutos útiles (1.5660b), y el menor peso promedio por fruto (254.89b). El estrato inferior fue el menos afectado.

Introduction

Among many pests affecting tomato (*Lycopersicon esculentum* Mill), the tomato russet mite, *Aculops lycopersici* (Massee), is one of the most damaging. The pest was first detected in Australia (Masse 1937) and has since dispersed worldwide (Jepson et al. 1975, Bastos 1981, Perring and Farrar 1986). Tomato is its main host (Jeppson et al. 1975), but it also affects other Solanaceae plants such as potato (*Solanum tuberosum* L.), eggplant (*Solanum melongena* L.), tobacco (*Nicotiana tabacum* L.), chili (*Capsicum* sp.), petunia (*Petunia* sp.), and nightshade (*Solanum nigrum* L.). It also affects species of Convolvulaceae such as bindweed (*Convolvulus arvensis* L.) and morning glory (*Ipomoea purpurea* L. Roth) (Bastos 1981, Gómez and Rivera 1987). *A. lycopersici* has extreme polyphagia, proliferates optimally in a

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large number of varieties of the genus *Lycopersicum*, and is cosmopolitan in distribution (López-Bautista et al. 2016).

The life cycle of *A. lycopersici* has four development stages and lasts an average of 7 days (Navarro et al. 2011, Schuster 2013). Adults are fusiform and robust, whitish to yellow-orange. Their main identifying characteristic is a tubercle of the seta of the dorsal shield directed posteriorly and divergent. The front lobe of the prodorsal shield has a lobulated edge; feather-claws on the legs have four rays (Jeppson et al. 1975, Keifer et al. 1982). Female adults live approximately 22 days and male adults live 16 days (Mau and Lee 1994). Females lay approximately 52 eggs (Haque and Kawai 2003), and Fernández (2011) reported the species does not diapause.

Optimal developmental conditions for the species were 27ºC and 30% relative humidity (Saini and Alvarado 2001, Haque and Kawai 2003). Under these conditions, a generation is completed in 6 to 7 days. They are most abundant in spring and fall (Saini and Alvarado 2001, Navarro et al. 2011).

A. lycopersici feeds on epidermal cells by using three types of stylets (15 µm long) that circle the mouth: chelicerae, labrum, and infra-capitulum. Chelicerae deposit saliva on epidermal cells, while the labrum and infra-capitulum form a feeding preorally-directed channel to suck cell contents (Nuzzaci and Alberti 1996). Feeding destroys epidermal cells, induces formation of insensitive tissues in damaged areas, and reduces photosynthesis and respiration (Royalty and Perring 1988). *A. lycopersici* establishes on the underside of leaves on the lower third of a plant (Fernandez 2011, Navarro et al. 2011). As abundance increases, it moves upward, and symptoms normally appear in the basal part of the plant and quickly propagate upward. The tomato russet mite is a major pest severely damaging all stages of tomato (Perring 1996) and causing serious economic loss (Royalty and Perring 1987, Duso et al. 2010). Typical symptoms of tomato russet mites are silver-colored rings on the lower surface of leaves that turn yellow to tannish-brown with a silvery appearance on the underside when the leaves dry and then fall off (Jeppson et al. 1975, Doreste 1984). Stems become bronze or cinnamon colored; the lower part loses its trichomes, cracking longitudinally, and eventually dies. Skin of green and ripe fruit becomes rough and brown. Fruit can become deformed and lose weight (Saini and Alvarado 2001, Kawai and Haque 2004, Navarro et al. 2011), and also is sunburned after leaves fall off (Jeppson et al. 1975, Doreste 1984).

A. lycopersici is microscopic in size (0.1 to 0.2 mm) and usually is not noticed until symptoms appear about 10 days after infestation, when abundant and difficult to control (Oliveira et al. 1982, Saini and Alvarado 2001, Navarro et al. 2011). Using tomato varieties with resistance to the pest is important for integrated management to reduce the need for insecticide. The aim of the study was to determine resistance of three varieties of tomato (SUN 7705, CID, and V305 F1) against *A. lycopersici.*

Materials and Methods

The study was done in a greenhouse at Colegio de Postgraduados, Campus Montecillo, Texcoco, State of Mexico (19º 27´ N; 98º 53´ W). Tomato varieties V305 F_1, CID, and SUN 7705 were selected for the study because they are the most commonly grown commercial varieties in the region. Seeds of all varieties were treated with *Bacillus subtilis* strain QST713 (Ehrenberg) Cohn 1872 and planted in plastic trays. Four weeks later, seedlings were transplanted into red volcanic (tezontle) substrate in polyethylene bags. Water and nutritive solution (Steiner) were provided (8 liters per hour) through an automated drip irrigation system.

The experimental unit was 10 tomato plants selected randomly from each variety. Three strata were used, with different plant height from base to apex: lower (0-13.77 inches), middle (13.78-27.55 inches), and upper (27.55-41.33 inches) with three replications of each variety, for 30 plants per variety and a total of 90 plants. Tomato plants were infested with mites 60 days after transplanting by putting an infested 5-cm stem into each plant stratum. The experimental design was randomized blocks.

Results of the experiment were obtained 60 days after infestation. Different racemes of tomato fruit on each plant stratum were evaluated. The measurement of the stratum changed because the plant grew from infestation to evaluation: lower (0-23.62 inches), middle (23.63-47.24 inches), and upper (23.64-70.86 inches). Each fruit of each raceme was divided into categories of: 1) damaged or not marketable when more than 20% of fruit was damaged and 2) acceptable for market when less than 20% of the fruit surface was damaged. The amount of damage per fruit was determined visually. All fruit in the "acceptable for market" category was weighed. An index of damaged fruit per raceme was calculated by dividing the total number of fruit by the number of damaged fruit (more than 20% damaged surface). The index of useful fruit was the total number of fruit divided by the number of acceptable fruit per raceme. Infestation density was determined by counting all live *A. lycopersici* on a square centimeter per damaged fruit, observed with a 10X magnifying glass.

Analysis of variance with sub-sampling was done for each variable by using a general linear model and Tukey test ($\alpha = 0.05$) in SAS v. 9.4. Correlation analysis also was done.

Results

Results of analysis of variance indicated damage to fruit in at least one stratum was significantly different ($F_{2,4} = 32.91$; $P = 0.003$). A Tukey test indicated the middle stratum had significantly more damaged fruit, followed by the upper stratum, and then the lower stratum (Table 1).

Fruit of variety V305 F_1 was most damaged ($F_{2,4} = 6.20$; $P = 0.0595$; $\alpha = 0.1$) (Fig. 1). Variety CID had the fewest damaged fruit and was more resistant to damage by *A. lycopersici*. Fruits of varieties CID and SUN 7705 from the three strata were damaged, but damage was most evident on V305 F_1. Correlation analysis indicated fruit that was more damaged ($\rho = 0.793$) was more infested by tomato russet mites.

At least one strata resulted in a greater useful fruit index ($F_{2,4} = 32.92$; $P = 0.0033$). The Tukey test indicated the lower stratum had the most useful fruit, followed by the middle and upper strata (Table 1). The number of *A. lycopersici* increased on the middle and upper parts where damage was significantly more ($P > F$, 0.0033). V305 F_1 had the lowest index of useful fruit ($P > F$, 0.0595) and CID had the greatest proportion in the lower and upper strata (Fig. 2). The middle stratum of variety CID and upper stratum of V305 F_1 had similar useful fruit indices. Correlation analysis ($\alpha = 0.1$) indicated the larger the number of useful fruit, the less the index of damage ($\rho = -1.000$).

Results of analysis of variance indicated the middle stratum had the least proportion of useful fruit per raceme ($F_{2,4} = 21.23$; $P = 0.0074$), followed by the upper and lower strata. V305 F_1 had the least number of useful fruit per raceme ($F_{2,4} = 7.98$; $P = 0.0401$) (Fig. 3). CID was the variety that yielded most, and had the greatest proportion of useful fruit per raceme. The middle stratum of the CID and upper stratum of Sun 7705 were not significantly different in terms of useful fruit per raceme because of vegetative development of the varieties. Correlation analysis (α = 0.1) indicated that the more useful fruit per raceme, the lower the index of damaged fruit (ρ = -0.929). Likewise, the greater the number of useful fruit per raceme, the greater the index of useful fruit (ρ = 0.928).

The middle stratum had the least average weight per fruit ($F_{2,4}$ = 11.64; P = 0.0215), followed by the upper and lower strata (Fig. 4). Comparing varieties at α =

Table 1. Results of Damaged Fruit indices of Tomato by Varieties (SUN 7705, V305 F_1) and Strata (lower, middle, upper) using the Test Comparing Means of Tukey (α = 0.05)

Variety and stratum	IDF	IUF	NUF	Weight	UWR	Density
SUN 7705	1.1711a	2.7020 a	12.910ab	373.83a	1530.9ab	205.19b
V305 F1	1.6852a	2.1878a	10.887b	302.97a	1074.8b	406.89a
CID	0.7927a	3.0803a	17.644a	460.31a	2739.3a	90.48b
Lower stratum	0.2549b	3.6181a	19.193a	502.40a	2626.4a	105.86b
Middle stratum	2.3070a	1.5660b	7.918b	254.89b	1198.5b	350.15a
Upper stratum	1.2549b	2.7860a	14.330a	379.82ab	1520.0ab	246.54ab

IDF: index of damaged fruit, IUF: index of useful fruit, NUF: average number of useful fruit, UWR: useful weight per raceme.

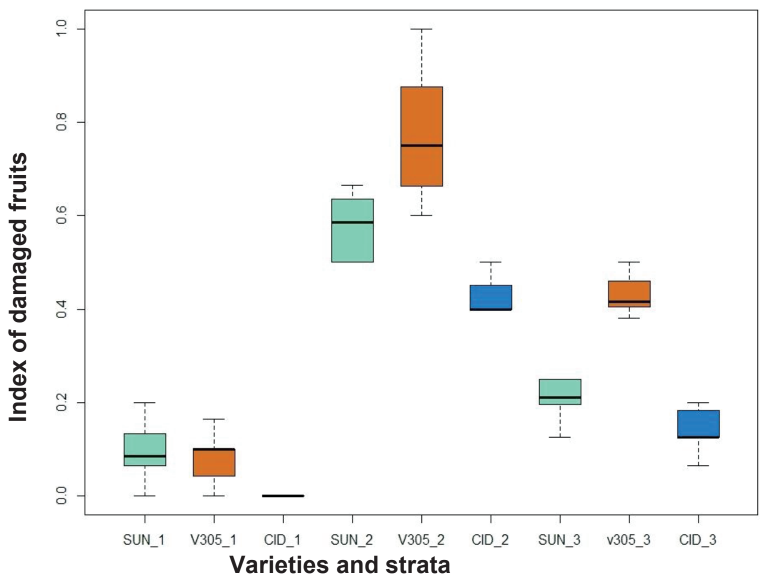

Fig. 1. Distribution of damaged fruit indices of tomato varieties SUN 7705 (box green), V305 F_1 (box orange) and CID (box blue) in three strata: 1 (lower), 2 (middle), and 3 (upper).

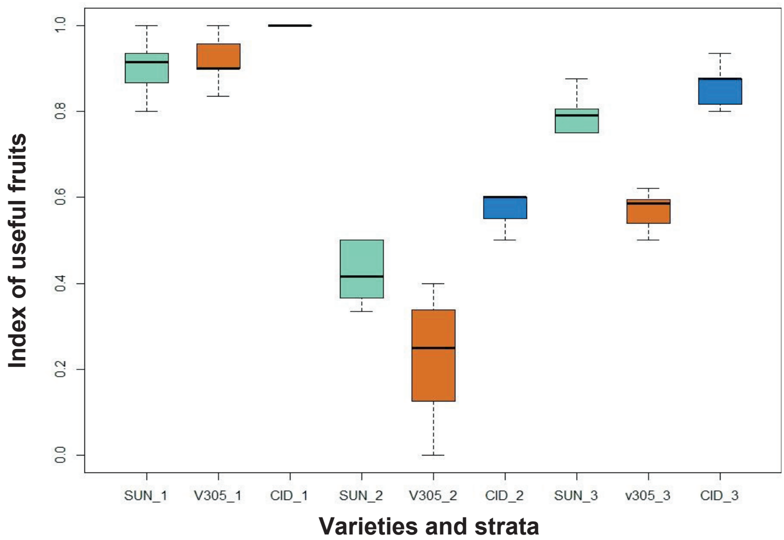

Fig. 2. Distribution of useful fruit indices of tomato varieties SUN 7705 (box green), V305 F_1 (box orange), and CID (box blue) in the three strata: 1 (lower), 2 (middle), and 3 (upper).

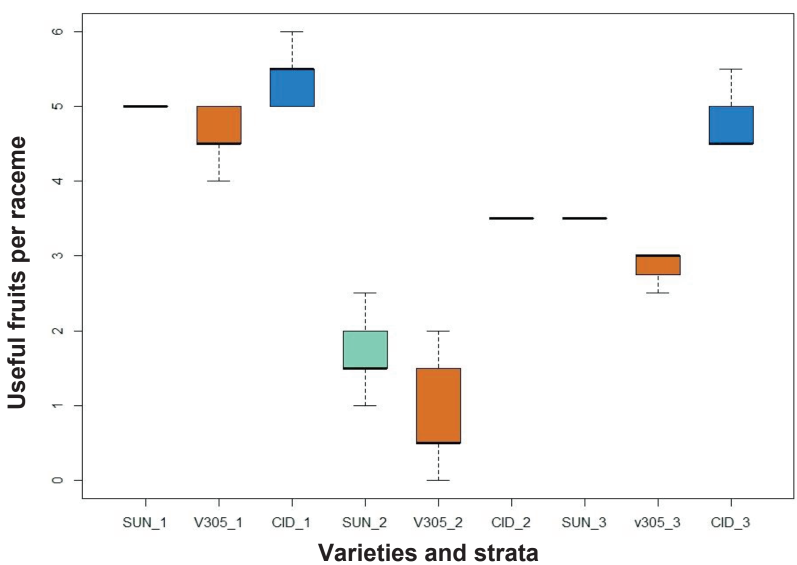

Fig. 3. Distribution of indices of useful fruit per raceme of tomato varieties SUN 7705 (box green), V305 F1 (box orange), and CID (box blue) in three strata: 1 (lower), 2 (middle), and 3 (upper).

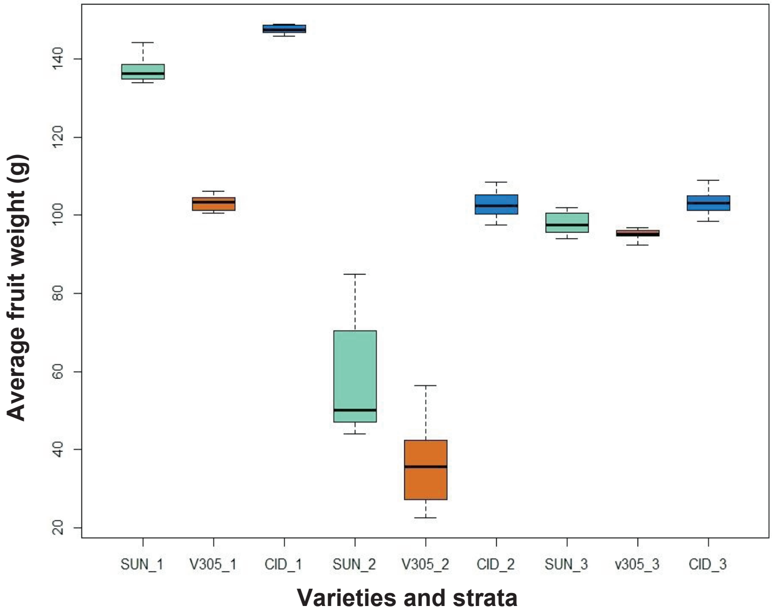

Fig. 4. Distribution of average fruit weight of tomato varieties SUN 7705 (box green), V305 F_1 (box orange), and CID (box blue) in three strata: 1 (lower), 2 (middle), and 3 (upper).

0.1, V305 F_1 had least fruit weight ($F_{2,4}$ = 4.72; P = 0.0886). CID had the greatest fruit weight and also had similar results in the middle and upper strata. A Tukey test indicated V305 F_1 was the variety with least average weight of fruit in the three strata. Correlation analysis showed that greater average fruit weight resulted in a lower index of damaged fruit (ρ = -0.846), and greater indices of useful fruit (ρ = 0.844) and useful fruit per raceme (ρ = 0.902).

Only useful fruit per raceme was considered in average raceme weight. Analysis of variance indicated the middle stratum had the least average weight per raceme ($F_{2,4}$ = 9.32; P = 0.0312), followed by upper and lower strata (Fig. 5). V305 F_1 had the least average fruit weight ($F_{2,4}$ = 12.29; P = 0.0196) of the three varieties. A Tukey test indicated the variety with the greatest fruit weight per raceme in the three strata was CID (Table 1). The lower stratum of the three tomato varieties had greater useful weight per raceme; *A. lycopersici* did not damage this plant stratum.

Correlation analysis at α = 0.1 determined the greater the average weight of useful fruit per raceme, the less the damage index (ρ = -0.753). The greater the average weight of useful fruit per raceme, the greater the useful fruit index (ρ = 0.750), number of useful fruit per raceme (ρ = 0.861), and average weight per fruit (ρ = 0.894). Analysis of variance (α = 0.05) of abundance of *A. lycopersici* in fruit indicated statistically significant differences ($F_{2,4}$ = 11.79; P = 0.020) among the three strata of tomato varieties. Results showed significantly more *A. lycopersici* in the middle stratum, followed by the upper stratum, while mites were least abundant in the lower stratum (Fig. 6). Tomato russet mites were significantly most abundant on V305 F_1

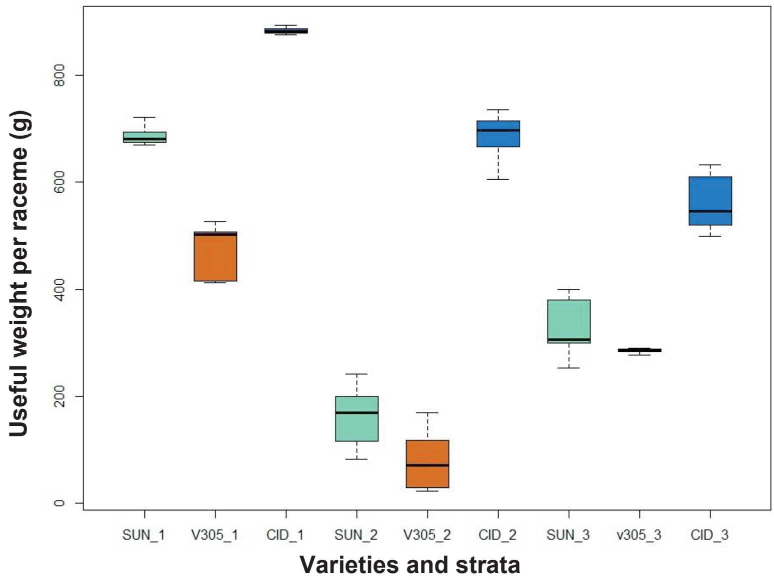

Fig. 5. Distribution of useful weight per raceme of tomato varieties SUN 7705 (box green), V305 F_1 (box orange), and CID (box blue) in three strata: 1 (lower), 2 (middle), and 3 (upper).

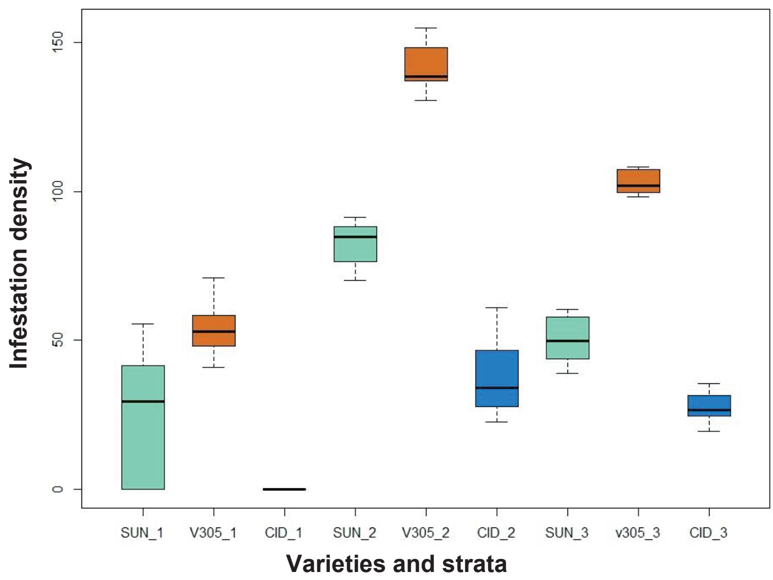

Fig. 6. Distribution of abundance of infestation by *Aculops lycopersici* in tomato fruit of varieties SUN 7705 (box green), V305 F_1 (box orange), and CID (box blue) in three strata: 1 (lower), 2 (middle), and 3 (upper).

($F_{2,4}$ = 20.12; P = 0.008; α = 0.1) and V305 F_1 in the three strata (lower, middle, and upper). A Tukey test indicated CID followed by SUN 7705 had fewest tomato russet mites in the three strata (Table 1).

Correlation analysis showed that the greater the abundance of *A. lycopersici*, the greater the index of damage (ρ = 0.793). More individual tomato russet mites, resulted in smaller numbers of useful fruit (ρ = -0.791), useful fruit per raceme (ρ = -0.802), average fruit weight (ρ = -0.769), and average raceme weight (ρ = -0.820).

Discussion

Tomato russet mites were most abundant on V305 F_1 that had a greater index of damaged fruit, lower index of useful fruit, and least average weight per fruit and per raceme. V305 F_1 was more susceptible to damage by tomato russet mite than was CID or SUN 7705. Earliness of V305 F_1 made it more susceptible because the mites had more time to feed and cause damage. According to Fernández (2011), *A. lycopersici* does not diapause phase and is present year around. For this reason, V305 F_1 is not recommended for production of tomatoes in a greenhouse, especially with history of mites. Under greenhouse conditions and in terms of commercialization, CID had the highest index of useful fruit and average fruit weight, low abundance of *A. lycopersici*, and better crop yield. *A. lycopersici* impacted yield of the varieties, and there was large correlation between mites and variables in the study. Lack of statistically significant differences in abundance of *A. lycopersici* in the three strata of the varieties was caused by mite saturation of the space where the data were collected. The short life cycle of *A. lycopersici* (7 days) was associated with high fecundity (51.7 eggs per female), which meant abundance increased exponentially in a few days (Haque and Kawai 2003, Navarro et al. 2011, Schuster 2013).

Results concurred with those of Oliveira et al. (1982), Saini and Alvarado (2001), and Navarro et al. (2011) in that symptoms by tomato russet mite were evident, in this case, damaged fruit, when mites were abundant. Damage in three strata of tomato plants agreed with Perring (1996) in that tomato russet mites damaged both old (lower) or young (upper) strata at any developmental stage of the crop. The fewer tomato russet mites on the tomato crop, the greater the number of fruit that can be marketed, as found by Oliveira et al. (1982), Saini and Alvarado (2001), and Navarro et al. (2011). The largest proportion of damaged fruit in the middle stratum and greatest useful fruit index in the lower stratum concurred with results of Doreste (1984), Saini and Alvarado (2001), Fernández (2011), and Navarro et al. (2011) because *A. lycopersici* abundance and damage moves upward, so mites in the lower part of the tomato plant were not abundant enough to damage fruit, while the number of *A. lycopersici* increased in the middle and upper parts where damage was significantly greater. Low weight of the tomatoes was caused by damage by *A. lycopersici*, concurring with Saini and Alvarado (2001), Kawai and Haque (2004), and Navarro et al. (2011). According to Royalty and Perring (1988) and Nuzzaci and Alberti (1996), low fruit weight was caused by tomato russet mite feeding: they feed on epidermal cells of the plant, reducing photosynthesis and respiration, which in turn decreases weight. The low average weight of fruit from the middle and upper strata means economic losses for a grower because it lowers crop production (Berlinger et al. 1982, Royalty and Perring 1987).

Our objective in determining the incidence of damage by *A. lycopersici* and how it affects yields of three tomato varieties was achieved. Abundant *A. lycopersici* caused visible damage on tomato fruit and reduced fruit weight, mainly in the middle stratum of the plant. Of the three varieties (CID, SUN 7705, and V305 F_1), V305 F_1 was most infested by *A. lycopersici*, followed by SUN 7705, and finally CID that was most resistant to damage by mites. V305 F_1 was most susceptible, having the greatest index of damaged fruit and greatest abundance of *A. lycopersici* as well as the lowest index of useful fruit and least average fruit weight. Variety CID is recommended for commercial tomatoes in a greenhouse when problems with *A. lycopersici* are recurrent, because in the study it had least incidence of damage, greatest index of useful fruit, more average fruit weight, and least mites. The variety yielded 45% more than did SUN 7705 and 61% more than V305 F_1. Of the three strata of the three varieties, the lower strata had least damage and infested fruit, as well as the greatest index of useful fruit and average useful fruit weight. This was because the plant continued to develop, and when old leaves were removed, *A. lycopersici* tended to move up to the next stratum. Less abundance of tomato russet mites in that stratum resulted in considerably less damage, while damage was greater in the middle and upper strata.

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