EFFECTS OF ROSE CULTIVARS AND FERTILIZATION RATES ON POPULATIONS OF *SCIRTOTHRIPS DORSALIS* (THYSANOPTERA: THRIPIDAE) IN SOUTHERN FLORIDA

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Abstract

Roses (*Rosa* spp. L.) are important ornamental hosts of chilli thrips, *Scirtothrips dorsalis* Hood (Thysanoptera: Thripidae). The knowledge of how these thrips affect 8 cultivars of landscape roses popular in Florida ('Angel Face', 'Don Juan', 'Pink Summer Snow', 'Radcon', 'Radrazz', 'Radsunny', 'St. Patrick', and 'Sun Flare') would help in developing techniques for integrated pest management of *S. dorsalis*. The effects of 3 rates of fertilizer and cultivars on population densities of chilli thrips and on host plant damage were evaluated. Fertilization rate, plant organ, and cultivar were important in determining *S. dorsalis* population density. Differences in total numbers of *S. dorsalis*, damage rating, and in numbers of flowers and buds produced were observed among different fertilizer rates. The higher rates recommended for accelerated floral growth resulted in more *S. dorsalis* damage, but not in more flowers than the rates suggested for maintenance. Among parts of the rose plant, buds had the highest density of *S. dorsalis*, followed by flowers and leaves, which had similar low densities. Larger flowers had more *S. dorsalis* than small flowers, but population densities were similar. Different cultivars of Knock-Out® rose were similar in their susceptibility to *S. dorsalis*, but 'Radcon', 'Don Juan', and 'Sun Flare' had more damage with lower *S. dorsalis* abundance and density than other the cultivars.

Key Words: Chilli thrips, damage rating, *Rosa* spp., plant parts

Resumen

Las rosas ornamentales (*Rosa* spp. L.) son huéspedes importantes para los trips de pimienta, *Scirtothrips dorsalis* Hood (Thysanoptera: Thripidae), por lo tanto, un conocimiento de sus efectos a los ocho cultivares de rosas populares en la Florida ('Angel Face', 'Don Juan', 'Pink Summer Snow', 'Radcon', 'Radrazz', 'Radsunny', 'St. Patrick', y 'Sun Flare') podria asistir en el desarrollo de técnicas para una programa de manejo integrado de los trips de pimienta. Los efectos de tres tasas de abono y cultivar en la densidad de población de trips pimienta y daño al planta huéspeda fueron evaluados. Tasa de fertilización, órgano de planta, y cultivar fueron importantes para determinar el densidad población de los trips de pimienta. Diferencias en el número total de trips pimienta, el daño, y el número de flores y brotes fueron observados en los tasas de fertilizante. Las tasas mas altas recomendadas por el crecimiento accelerado de flores resultaron en mas daño por los trips de pimienta y no en mas flores que niveles de fertilizantes recomendados para el mantenimiento de las plantas. Entre los organos de la planta rosa, los brotes tuvieron la densidad mas alta de los trips pimienta, seguido para las flores y las hojas, que tuverion densidades parecidos y bajas. Las flores más grandes obtuvieron mas trips de pimienta que flores pequeños, pero sus densidades poblaciónes fueron parecidos. Las cultivares diferentes de rosa Knock-Out® fueron parecidos en sus susceptibilidades de los trips pimienta, pero 'Radcon', 'Don Juan', y 'Sun Flare' obtuvieron mas daño con menos abundancia y densidad de trips pimienta de las otras cultivares .

Palabras Claves: Trips de pimienta, calificaciónes de daños, *Rosa* spp., partes de planta

Scirtothrips dorsalis Hood (Thysanoptera: Thripidae), chilli thrips, is a problematic pest native to southern Asia (Dev 1964; Kumar 2012). It has rapidly expanded its range over the last 20 yr into much of the world's tropical and subtropical regions. In 2005, *S. dorsalis* was first found established in Florida (Coolidge 2005; Silagyi & Dixon 2006) and Texas (Holtz 2006) and shows considerable potential for expansion into the remainder of North America (Venette & Davis 2004; Meissner et al. 2005; Nietschke et al. 2008). *Scirtothrips dorsalis* attacks more than 112 plant species in about 40 different families (CABI/EPPO 1997; CABI 2003), and it affects fruit and vegetable hosts of economic significance including cotton (*Gossypium* spp. L., Malvales: Malvaceae), peanut (*Arachis hypogaea* L., Fabales: Fabaceae), soybean (*Glycine max* (L.) Merr, Fabales: Fabaceae), strawberry (*Fragaria* × *annanasa* Duchesne, Rosales: Rosaceae), pepper (*Capsicum* spp. L., Solanales: Solanaceae), mango (*Mangifera* spp. L., Sapindales: Anacardiaceae), and citrus (*Citrus* spp. L., Sapindales: Rutaceae) (Venette & Davis 2004; Meissner et al. 2005; Nietschke et al. 2008). *Scirtothrips dorsalis* also attacks ornamental plants and is a major pest of rose for the cut-flower industry in India where it reduces the quality, number, size, and appearance of flowers (Onkarappa & Mallik 1998; Duraimurugan & Jagadish 2004a). Symptoms of *S. dorsalis* feeding damage include stunted, scarred, deformed growth, leaf drop, and the leaves, sepals, and petals develop a bronzed, scorched scarring (Dev 1964; Mound & Palmer 1981; Chandrasekaran 2005). Some researchers suggest that a protease in the saliva may contribute to the damage (Dev 1964; Raizada 1965). *Scirtothrips dorsalis* destroys plant epidermal and mesophyll cells when it feeds (Heming 1993; Kirk 1995). Hence, higher densities of *S. dorsalis* may cause more damage than host plants can replace and can kill them (Mound & Palmer 1981), and plants damaged by *S. dorsalis* become unattractive, thus unsalable.

Gahukar (2003) reported that there was high variation in *S. dorsalis* population abundance among rose cultivars and from year to year. 'Gladiator' had the highest abundance of *S. dorsalis* in flowers of different sizes and the highest infestation rates. Also, flower color affected *S. dorsalis* population distribution with red flowers having more *S. dorsalis* than orange or yellow flowers (Gahukar 2003).

The Knock-Out® rose, *Rosa* 'Radrazz' ('Carefree Beauty' × 'Razzle Dazzle'), has single red flowers, and a round, shrubby growth habit (Radler 2001), and has become popular in Florida because of its abundant flowers, low maintenance, and strong resistance to black spot disease, *Diplocarpon rosae* Wolf (Ascomycota) in Florida's humid environment (Radler 2001, Brown 2007). Unfortunately, *R.* 'Radrazz' has also become an important host of *S. dorsalis* (Silagyi & Dixon 2006), which has affected its sales in Florida nurseries. The Sunny Knock-Out®, *R.* 'Radsunny' ('Radbrite' × 'Radsweet') also has single flowers, a round, shrubby growth habit, and excellent resistance to blackspot disease. Unlike *R.* 'Radrazz', *R.* 'Radsunny' produces bright yellow flowers that fade to white as they age, and the petioles release a strong "sweetbriar" odor (Radler 2001, 2008). The susceptibility of *R.* 'Radsunny' to *S. dorsalis* has yet to be determined. Pink Knock-Out®, *Rosa* 'Radcon' (a mutation of `Radrazz`) has single, pink flowers, compact, mounding growth habit, and excellent resistance to blackspot disease (Montesino 2004). *Rosa* 'Angel Face' [('Circus' × 'Lavender Pinocchio') × 'Sterling Silver'] is a lavender-flowered hybrid tea rose with an upright, bushy, compact growth habit (Wikipedia 2012). *Rosa* 'Don Juan' ('New Dawn' × 'New Yorker') is a dark-red-flowered, climbing rose (Jackson & Perkins 2012) and 'Pink Summer Snow' (a sport of 'Summer Snow') is considered a cluster-flowered type rose, which includes floribunda and grandiflora roses, has pink flowers, and is a shrub (Dave's Garden 2012a). *Rosa* 'St. Patrick' ('Brandy' × 'Gold Medal') is a hybrid tea rose with double yellow flowers and a bushy growth habit (Dave's Garden 2012b), and 'Sun Flare' ('Sunsprite' × unnamed variety) is a floribunda class rose with yellow flowers, which grows into a 0.6-to-1.2-m tall shrub (Wikipedia 2010). Seven of these 8 varieties have been patented with the United States Patent and Trademark Office: all except 'Pink Summer Snow' (Radler 2001, 2008; Montesino 2004; Wikipedia 2010, 2012; Dave's Garden 2012a, b; Jackson & Perkins 2012; USPTO 2012).

Plants provided with high nitrogen fertilization are often more attractive to insect pests than those provided with less nitrogen (Slansky & Rodriquez 1987). Thus, a common nursery practice of adding nutrients to promote or "push" the growth of ornamental plants may be causing *S. dorsalis* populations to increase. Heavily fertilized plants have more free amino acids in their tissues allowing for more rapid growth of the plant and of populations of insects that feed on them (Mattson 1980). Fertilized plants may have larger plant heights and produce more and larger flowers, which provide additional attractive cues to pests. Elevating quantities of fertilizer increased the population growth rate of *Frankliniella occidentalis* (Pergande) (Thysanoptera: Thripidae) compared to lower fertilization rates (Chau et al. 2005). However, higher insect growth rates with higher host plant fertilization is mediated by specialized secondary compounds produced by resistant cultivars (Schuch et al. 1998) or by other factors such as season (Salguero-Navas et al. 1991; Cho et al. 2000; Reitz 2002) or host plant phenology. For example younger plants may support higher population densities than older plants (Reitz 2002). Nevertheless, Duraimurugan & Jagadish (2004b) observed larger populations of *S. dorsalis* with higher fertilization rates on rose, and Varghese & Giraddi (2005) suggested fertilizing chili peppers with only 50 percent of the recommended rate combined with the use of azadirachtin insecticide to control *S. dorsalis*.

Because *S. dorsalis* may thrive in both agricultural and ornamental landscapes, growers and homeowners should apply an integrated pest management program to prevent development of pesticide resistance. Knowledge of the effects of *S. dorsalis* on other rose varieties would be helpful in developing integrated pest management techniques. The purpose of the present study was to evaluate effects of fertilization rate and cultivar on the population density of *S. dorsalis* and resulting host plant damage.

Materials and Methods

All tests were performed at the University of Florida, Tropical Research and Educational Center (TREC), Homestead, during 2008. All test plants were exposed to ambient environmental conditions throughout the experiments and irrigated with 93 ± 15 ml of tap water twice daily at 6:00 AM and 2:00 PM EST by an overhead sprinkler system with a timer and following local water restrictions and extension office suggestions. Total numbers of flowers and vegetative buds on each plant were counted biweekly to estimate the reproductive output of each plant. A damage estimate similar to that described by Kumar et al. (1996) for pepper was developed during preliminary observations and was used weekly to rate plant damage from 0 for no symptoms to 5 for defoliated plants near death. For consistency, all samples of leaves, buds, and flowers were removed with pruning shears and promptly sealed in small plastic containers with 2 drops of 95% ethanol. Samples that could not be immediately processed were frozen at -6 °C until processing; only mature leaves, buds, and flowers of a similar age were sampled. Plant samples were dried overnight and the area of each dried sample was determined using a leaf area meter (LI-3000, Li-Cor, Lincoln, Nebraska) to allow calculation of the density of *S. dorsalis* in each sample (*S. dorsalis* per cm^2). The quantity and life stages of *S. dorsalis* in a sample were determined by washing samples with 75% ethanol and pouring the runoff through a 25-µm mesh as described by Seal & Baranowski (1993) and the resulting debris was examined under a dissection microscope at 6X-12X magnification. Funderburk et al. (2007) was a primary aid for identification using morphological characters. Insect voucher specimens were collected and sent to the Florida Department of Agriculture and Consumer Services, Division of Plant Industry, Gainesville, for preservation and to confirm species identification throughout the experiment.

Test 1. Fertilizer Rates With 'Radsunny' and 'Radrazz' Cultivars

From Aug to Oct 2008, a comparison was made on the effects of fertilizer rates on 'Radrazz' and 'Radsunny' rose cultivars. Twenty-four bare-root rose plants each of 'Radrazz' and 'Radsunny' provided by the Conard-Pyle Company (Wilmington, Delaware) were grown in a greenhouse free from *S. dorsalis*. Plants were grown individually in 11-liter containers using a standard potting medium: 50% Canadian sphagnum peat moss, 25% processed pine bark, and 25% a mixture of perlite and vermiculite (Fafard 3B Mix, Conrad Fafard Inc., Agawam, Massachusetts) for 3 mo then transferred to an outdoor growing area. The plants were then exposed to 'Radrazz' roses infested with 3 *S. dorsalis* per cm^2 on the flowers. Four replications each with 1 of each treatment and cultivar were randomly placed within a 6-by-8-plant grid that provided 33 cm separation between plants. Eight plants of each cultivar were randomly assigned to 1 of 3 fertilizer treatments. The "high rate" treatment involved 7.9 g of 20-20-20 liquid fertilizer (Peter's Professional, Scotts Company, Marysville, Ohio) every 2 wk and 13 g of 15-9-12 granular fertilizer (Osmocote Plus, Scotts Co., Marysville, Ohio) every 2 mo. The maintenance rate treatment used 4.0 g of liquid fertilizer once a mo and 7.5 g of granular fertilizer once every 2 mo. Control plants received no solid fertilizers and only water when plants in the other treatments received liquid fertilizer. Plant samples were collected every 2 wk from 1 Sep to 22 Oct 2008. Estimates of *S. dorsalis* populations were made by randomly sampling a bud or flower from each plant every 2 wk at 3:00 PM EST as described by Duraimurugan & Jagadish (2004a).

Test 2. Susceptibility of 6 Cultivars

The second experiment (Sep to Nov 2008) compared populations of *S. dorsalis* on 6 rose cultivars 'Angel Face', 'Don Juan', 'Radcon', 'Pink Summer Snow', 'St. Patrick', and 'Sun Flare'. Five plants of each of the 6 cultivars were donated in 11-L containers by Nelson's Florida Roses, Apopka, Florida, then transported to TREC on 9 Sep 2008 and exposed to naturally occurring *S. dorsalis* populations. Five replications with 1 plant from each of the 6 cultivars were randomly placed within a 5-by-6-plant grid that provided 33 cm of separation between plants. One bud, 1 flower and 1 leaf were sampled from each plant at approximately 3:00 PM EST once every 2 wk to determine within-plant pest distributions based on methods of Onkarappa & Mallik (1998). Plant samples were collected on 9 Sep 2008, and then biweekly from 11 Sep to 11 Nov 2008.

Statistical Analyses

A two-way ANOVA was initially used to test for interaction between cultivar and fertilizer rate in the first test and cultivar and time in the second test. For both tests, the numbers and densities of *S. dorsalis* were transformed by applying the square root to homogenize variance before analysis. The number and size of flowers, number and density of *S. dorsalis*, their proportion at each life-stage, and damage levels for each cultivar and fertilizer treatment were compared among treatments by one-way ANOVA using JMP statistical software (SAS Institute 2007). Means from the first experiment were separated using pairwise T-test comparisons, and by Tukey-Kramer HSD in the second experiment. Least-square means were also used to fit the general linear model and determine the strength of relationships between different factors in each experiment.

Results

Test 1. Fertilizer Rates With 'Radsunny' and 'Radrazz' Cultivars

In the first experiment, no significant interactions were found between cultivar and fertilizer rate for any of the variables tested. Thus, fertilizer treatments were pooled to compare cultivars and cultivars were pooled to compare fertilizer treatments. No significant differences were found between 'Radrazz' and 'Radsunny' cultivars for abundance of *S. dorsalis* at any life stage or sex, densities, damage rating, floral area, or the number of flowers and buds produced (data not shown). However, both the maintenance and high rates of fertilizer resulted in a significantly higher weekly total number of *S. dorsalis* than the control (F = 3.46; df = 2, 232; P = 0.0330) (Fig. 1). Significant differences also occurred for weekly number of larvae (F = 3.99; df = 2, 232; P = 0.0197) and of adults (F = 3.24; df = 2, 232; P = 0.0411). Damage rating was also significantly higher for the high fertilizer rate than for the control (F = 5.07; df = 2, 232; P = 0.0070) (Fig. 2). Further analysis by week showed that differences in total numbers of *S. dorsalis* increased and became significant for wk 5 (F = 3.32; df = 2, 44; P = 0.0455) and 7 (F = 4.53; df = 2, 44; P = 0.0162) (Fig. 3). There were no significant differences between fertilizer treatments in mean density of *S. dorsalis*, in total of flowers or of buds, or in mean area of flowers (data not shown).

Test 2. Susceptibility of 6 Rose Cultivars to *S. dorsalis*.

No significant interaction was observed between cultivar and time for *S. dorsalis* abundance, density, or damage. *Scirtothrips dorsalis* density generally increased on all hosts for the first 3-5 wk, then tended to remain constant (Fig. 4). After 5 wk, *S. dorsalis* was found on all plants of all rose cultivars tested. Although no significant interaction was found, cultivar (F = 3.55, df = 5, P = 0.0037) and plant organ (F = 96.09, df = 2, P < 0.0001) each appeared to significantly affect *S. dorsalis* densities. When weekly data were pooled, there was a significant difference in total *S. dorsalis* density between cultivars (F = 2.23; df = 5, 519; P = 0.0496) (Fig. 5). 'Radcon' numerically had the highest *S. dorsalis* density and was significantly higher than 'Sun Flare' or 'Angel Face'. Plant organs also showed significant differences in *S. dorsalis* density (F = 89.14; df = 5, 519; P < 0.0001) with buds having significantly higher densities than flower petals or leaves (Fig. 6). While no plant had a damage rating greater than 1 during the experimental period, a significant difference was found in mean damage rating

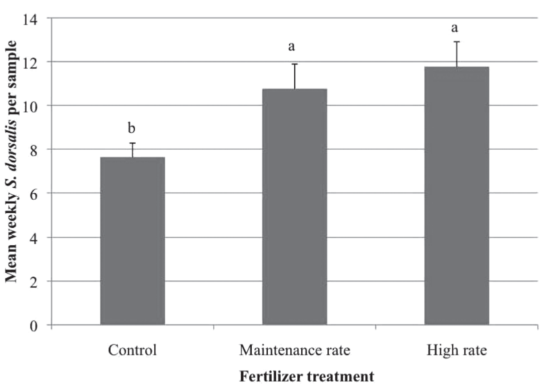

Fig. 1. Mean ± SD of weekly numbers of *Scirtothrips dorsalis* per floral sample for each fertilizer rate in Test 1. Different letters indicate significant differences among fertilizer treatments according to a multiple pairwise T-test comparison.

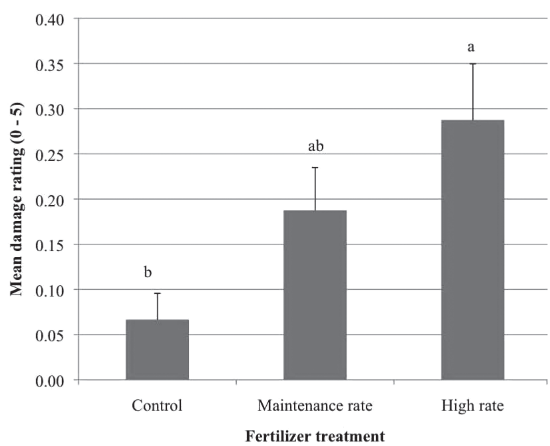

Fig. 2. Mean ± SD rating of damage by *Scirtothrips dorsalis* for each fertilizer treatment in Test 1. Different letters indicate significant differences among fertilizer treatments according to multiple pairwise T-test comparisons.

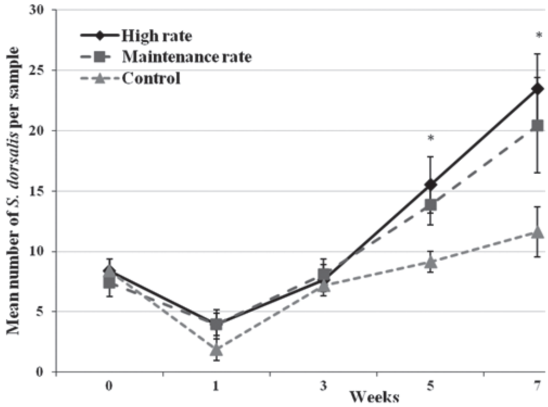

Fig. 3. Weekly mean ± SD total numbers of *Scirtothrips dorsalis* for three fertilizer rates in Test 1. An asterisk (*) indicates that high and maintenance rates were significantly different from the control treatment according to multiple pairwise comparisons.

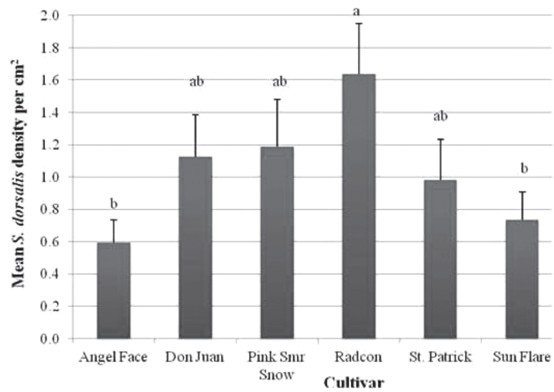

Fig. 5. Mean ± SD *Scirtothrips dorsalis* density of each cultivar in Test 2 with weekly data pooled. Different letters indicate significant differences among cultivars according to a Tukey-Kramer HSD test.

per cultivar ($F = 5.42$; df = 5, 519; $P < 0.0001$) with 'Radcon', 'Don Juan', and 'Sun Flare' each significantly higher than 'Angel Face' (Fig. 7).

Discussion

For container production, the "high rate" fertilizer treatment was recommended by local growers to accelerate plant growth, while the "maintenance rate" was recommended to "maintain" plants. Plants fertilized at the highest rate showed greater damage than the control treatment, and this may have been partly due to larger populations of *S. dorsalis* found on these plants. *Scirtothrips dorsalis* was more abundant on hosts that were fertilized than on unfertilized hosts but its density was similar among the 3 fertilizer rates, which may have allowed *S. dorsalis* to exploit resources with minimum competition. With higher *S. dorsalis* populations and pest pressure, crowding may begin to occur, and there may be an upper limit on *S. dorsalis* population density or on the number that can feed simultaneously on a host plant. The recommendations by Varghese & Giraddi (2005) to reduce fertilizer use on chili by 50 percent may also help to limit *S. dorsalis* populations and their damage to cultivars such as *R.* 'Radrazz'". This fits with our observation of roses in urban landscapes. Populations are much

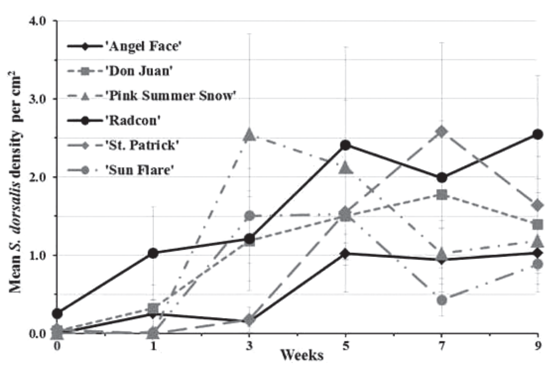

Fig. 4. Mean ± SD weekly *Scirtothrips dorsalis* density for each cultivar in Test 2 from mid-Sep to mid-Nov.

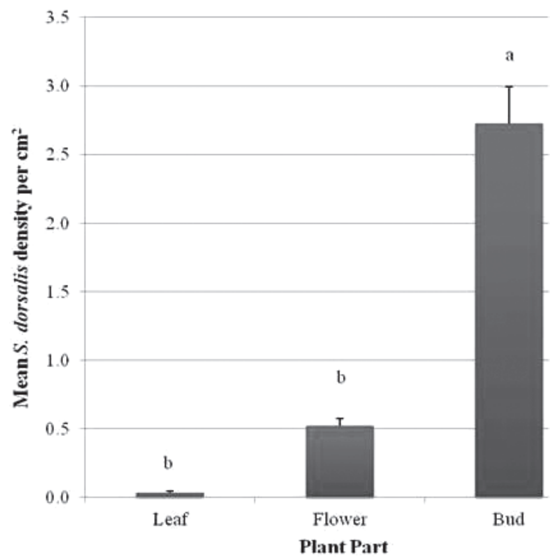

Fig. 6. Mean ± SD *Scirtothrips dorsalis* density on different plant organs sampled in Test 2. Different letters indicate significant differences among plant organs according to a Tukey-Kramer HSD test.

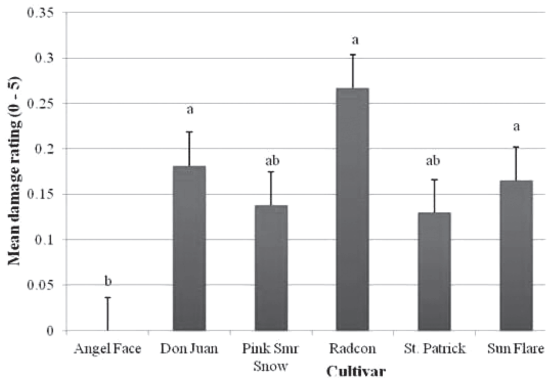

Fig. 7. Mean ± SD rating of damage by *Scirtothrips dorsalis* for each cultivar averaged over nine weeks of exposure for Test 2. Different letters indicate significant differences among cultivars according to a Tukey-Kramer HSD test.

lower in poorly maintained roses compared to those that are fertilized and watered regularly.

Damage to plants in both experiments did not exceed a rating of 2 on a 0-to-5 scale. New growth was wrinkled, and scarring occurred along the vein bases, most sepals, and the outer petals and most leaves were often stippled. A damage rating of 1 denoted damage to some sepals, but few petals and leaves were stippled. The limited range in feeding damage observed made it difficult to draw strong conclusions about relationships between *S. dorsalis* numbers or density and damage, hence, these relationships may have been better described by a different damage rating scale. Therefore, our scale helped to predict numbers of larvae and adults detected in flowers, but could not account for much of the variation present in populations. The low plant damage ratings may not be unusual for *S. dorsalis* behavior during the fall, when this experiment was conducted in south Florida. Also, *S. dorsalis* density and plant damage may increase on all cultivars during favorable conditions for the thrips, thereby causing more pest pressure and increasing differences in cultivar responses to the pest. In addition, *S. dorsalis* may not perform the same when multiple cultivars are present as when only 1 cultivar is present. In such a no-choice situation, some cultivars (when tested individually) may show higher levels of *S. dorsalis* damage, abundance, or density than other cultivars. Although a predictive relationship of *S. dorsalis* numbers or density to damage could not be described, the damage seemed more predictive of larval than of adult populations and of *S. dorsalis* numbers than density. While the 'Radrazz' (red-flowered) and 'Radsunny' (yellow-flowered) rose cultivars can be distinguished by foliar appearance, petal color, and floral scent, *S. dorsalis* populations seemed to be evenly distributed between both cultivars. This seems surprising because *S. dorsalis* has been captured in greater frequencies on yellow (Tsuchiya et al. 1995; Chu et al. 2006) or yellow and green (Tsuchiya et al. 1995) sticky traps than traps of other colors such as blue or white. However, Rani & Sridhar (2003) and Gahukar (2003) recovered more *S. dorsalis* adults on red or orange than on yellow rose petals in a small-arena choice-test. While these results may appear to conflict, *S. dorsalis* may use different cues and selection criteria to choose hosts at different spatial scales. The choice tests of Rani & Sridhar (2003) and Gahukar (2003) occurred in small arenas within the lab, while Tsuchiya et al. (1995) and Chu et al. (2006) performed choice tests in the field. Comparing these observations to results of the second experiment in the present study suggests that at a range of less than 1 meter, *S. dorsalis* may not choose between the 2 rose cultivars using criteria obvious to humans, such as color or scent, and other factors may be more important to local *S. dorsalis* dispersal and distribution.

There was no interaction between plant organ and cultivar suggesting that *S. dorsalis* will exploit all roses in a similar fashion, although they were found on some plant organs and on some varieties in greater densities than on others. Shibao et al. (1990) observed that populations of *S. dorsalis* were similar between 2 varieties of grape, but there were internal distributional differences. While *S. dorsalis* densities are valuable for comparing different rose species or cultivars, total numbers of *S. dorsalis* may be important to study population expansion and control. Larger populations are better able to persist through catastrophic ecological events and increase pressure on surrounding environments (Memmott et al. 1997; Fagan et al. 2002) especially if the larger roses have a larger floral area or produce large numbers of buds. *Scirtothrips dorsalis* was found in higher densities on buds than on flowers or leaves of roses. In addition, many thrips appear to prefer the upper part of the plant canopy and the outer extremities of their hosts (Reitz 2002; Hansen et al. 2003). However, removing growth terminals in citrus caused an increased migration of *S. dorsalis* away from de-budded plants (Shibao et al. 1993; Shibao 1997). *Scirtothrips dorsalis* may prefer these meristematic regions (buds) because nutrients flow towards them in plants (Lewis 1997). This is generally supported by research about *S. dorsalis* on *Capsicum annuum* L. (chili pepper) (Seal et al. 2006) and *Camellia* spp. L. (Ericales: Theaceae) (Dev 1964) in which thrips preferred younger plants and newer growth over older plants and growth. Also, *S. dorsalis* females prefer to oviposit inside buds and young leaves at apical meristems, but as populations increase, will oviposit within surfaces of mature leaves (Dev 1964; Raizada 1965). After hatching, larvae migrate from older leaves to the newer growth near apical meristems (Onkarappa & Mallik 1998). Although *S. dorsalis* was not present in high densities on leaves, the distinctive feeding damage of larvae provided evidence of their presence; more importantly, *S. dorsalis* occurred on leaves and flower petals at similar densities. *Scirtothrips dorsalis* is often found in flowers and terminal shoots in vegetables and ornamental plants (Shibao et al. 1993), and within flowers, it feeds on pollen (Saxena et al. 1996). In an olfactometer test, Saxena et al. (1996) showed that a greater number of *S. dorsalis* were attracted to pollen scents than to those of nectar or other plant tissue. However, plants are mostly non-floral leaves, stems, and buds, and most of the infestation symptoms of stunted, bronzed, deformed growth, and leaf drop are foliar (Dev 1964; Mound & Palmer 1981; Chandrasekaran 2005). Hence, *S. dorsalis* may be described as either a flower or foliar thrips. *Scirtothrips dorsalis* may thrive equally well on both substrates, and other factors such as precipitation, predation, or competition may largely determine the distribution of populations within host plants.

In the second test, 'Radcon', 'Don Juan', and 'Sun Flare' each had a higher damage rating than 'Angel Face', which numerically had the lowest rating, and 'Radcon' also was higher in *S. dorsalis* density than 'Angel Face'. 'Radcon' is a spontaneous mutation of `Radrazz` (Montesino 2004), thus, more closely related to `Radrazz` than to the other varieties in the test, which are hybrids or sports of other varieties. Hence, these findings support the initial belief by extension agents that *R.* 'Radrazz' is an important host to consider when surveying for *S. dorsalis* (Silagyi & Dixon 2006). Numerically, 'Radcon' had the highest *S. dorsalis* density and was significantly higher than 'Sun Flare' or 'Angel Face'. With *S. dorsalis* density, the small-flowered varieties, 'Radcon' and 'Pink Summer Snow', were not different from the large-flowered varieties, 'St. Patrick' and 'Don Juan'. Gahukar (2003) found that large, open flowers can support larger numbers of *S. dorsalis*, but smaller, more compact flowers can have a relatively high density of *S. dorsalis*. These hosts may provide similar environments for *S. dorsalis*, and vegetative size should determine total *S. dorsalis* population. Other varietal characteristics of roses may also affect *S. dorsalis* density: for example, in the second test, 'Angel Face' was numerically the lowest in *S. dorsalis* damage rating and population density among 6 rose varieties. This may represent host plant resistance preventing *S. dorsalis* growth, or a repellence of *S. dorsalis* based on the structure and chemistry of a particular cultivar and perhaps merits further testing. With this low rate of infestation and damage, 'Angel Face' may be the best choice among the cultivars we tested for the home landscape; similarly, 'Radcon' numerically had the highest population density and damage rating and may be 1 of the worst choices.

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