Insecticidal and Yield Enhancement Qualities of Surround Particle Film Technology in Citrus[1]

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Abstract

Surround WP was evaluated at various spray volumes to determine if volumes lower than the label recommended volume of 250 gallon per acre would provide equivalent citrus thrips control and yield enhancement potential. All the spray volumes evaluated (50, 100, 150, and 250 gpa) appeared to be equally effective. It appears that as long as the spray coverage appears to be visually adequate, then coverage is sufficient. Application of Surround WP led to some increase in fruit size, particularly for the first harvest.

Introduction

Surround WP represent a new and unique approach to managing thrips, *Scirtothrips citri* (Moulton) in citrus. Unlike conventional insecticides that control citrus thrips through rapid curative action, Surround WP appears to act primarily as a repellent. Surround WP is a hydrophobic mineral particle film applied in water that forms a bright white physical barrier protecting plants against certain insects and diseases. Although the plants are covered in a white film, there is no evidence that Surround WP interferes with photosynthesis or stomatal conductance. The Surround WP label specifies that it should be applied in a minimum of 250 gallons per acre (gpa) spray volume. However, due to sprayer configuration and speed of application considerations, most Arizona citrus producers are reluctant to exceed 100 gpa spray volumes.

In addition to its action against insects, in other tree fruits, Surround WP has been shown to protect against sunburn, and decreases heat stress leading to better fruit retention, size, and yield. Preliminary data has suggested that Surround may enhance yield in citrus as well. However, more data is needed to confirm this finding.

In this study we compare the effects of conventional insecticides versus Surround WP on the development of thrips populations and subsequent scarring on lemons when applied at various spray volumes. We also report information concerning the effects of Surround WP on yield and fruit size in lemons.

Materials and Methods

Twelve-year old 'Limoneira 8A Lisbon' lemon trees grown on the Yuma Mesa were used in these studies. The test was a split-plot design consisting of four replicates. It consisted of six main plots: an untreated, a commercial standard (Carzol SP at 1.0 lbs/ac + applied at 100 gpa), and Surround WP at 75 lbs/ac applied at 50, 100, 150, or 250 gpa. There

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were two sub-plots: Surround WP at the various spray volumes applied as needed until 85% of the fruit equaled or exceeded 1.0 inch in diameter, and a additional Surround WP application at the various spray volumes on 21 July. The July application was not intended to protect the crop from insect pests, but to offer additional protection against excessive temperatures. All treatments were applied using a PTO driven orchard sprayer. The size of each sub-plot was 3 x 7 trees (0.2 ac), with trees being spaced 28 ft apart.

Percent-infested fruit were estimated by sampling 50 fruit per plot for the presence or absence of immature citrus thrips. Applications and evaluation continued until approximately 85% of the fruit on the tree were 1.0 inch or greater in diameter. Fruit damage was estimated on 25 September, by rating the degree of scarring to the rind. Scarring was rated as 1=no scarring, 2=slight scarring partially around the stem, 3= scarring encircling the stem, 4=slight scarring on the side of the fruit and 5=major scarring on the side of the fruit. Fruit with a damage rating of 1 or 2, are not considered to be scarred heavy enough to cause a downgrade in quality. Fruit with a rating of 3 are considered sufficiently scarred to be downgraded to choice and fruit with a rating of 4 or 5 are considered suitable for juice. Because all sub-plots were treated equally during the period of susceptibility to thrips, fruit infestation and scarring data were pooled across sub-plots containing the same main plot treatment. Differences among insecticide treatments for thrips infestation and fruit damage were separated using ANOVA and an F protected LSD, $P<0.05$.

Fruit from each tree was harvested by hand using professional pickers from a local packinghouse. The experimental block was harvested three times, on 9/25/2000, 11/15/2000 and 1/5/2001. For the first two harvests, the pickers sized the fruit on the tree, using a metal ring with a diameter of the minimum marketable size as determined by the packinghouse. For the final harvest, all the remaining fruit marketable fruit were picked. Fruit from each subplot was harvested into 1500 lb wooden bins. Yields for each row were estimated as whole and fractional bins of harvested fruit. Yield data, expressed in lbs. fruit per subplot (21 trees) were collected only for the 11/15/2000 and 1/5/2001 harvests, since total yield data for the 9/25/00 harvest was lost.

For each of the three harvests, from 15 to 45 kg. of fruit was sampled from the fruit in of each bin, and size (packout) data were collected from this sample. All fruits per tree were sized using a portable optical fruit grader (Autoline, Inc., Reedley, CA). Each fruit that passed through the sorter was photographed and weighed. Weight, color, and fruit diameter data was collected for each fruit. Fruit was not physically sorted, but the data collected was stored in a laptop computer that is an integral part of the sorter. All fruit size results are reported on a percentage basis.

Results and Discussion

Citrus thrips were extremely low among all plots in this study throughout the season. Based on an action threshold of 10% infested fruit, thrips populations never reached damaging levels during the period of fruit susceptibility (Figure 1). Because Surround WP is thought to act primarily as a repellent, treatments were applied preventively being initiated just prior to full petal fall on 29 March. A second application of Surround WP was made on 12 April to insure coverage of new growth. Although, the commercial standard never exceeded the action threshold, because the thrips population had increased to 6% infested fruit on 19 May, and we were working in a commercial grove, we chose to treat the standard with Carzol SP on 19 May. Overall, there were only minor statistical differences among the treatments that did not equate into commercial differences. On 1 May, the standard contained significantly more infested fruit, 2.5%, than the other treatments which average 0 to 0.5% infested fruit, and on 25 May when the untreated had more infested fruit, (7.0%) than all the treatments but Surround WP at applied at a volume of 250 gpa which had 4.5% infested fruit.

Once 85% of the fruit at reached at least 1 inch in diameter in mid June, thrips populations rose in all treatments except the standard (Figure 1). Since the fruit was no longer at risk of significant scarring due to thrips, no action was taken. The reason the thrips populations increased in the Surround WP treated plots in mid June was probably due to a lack of coverage on the new growth since the last Surround WP application was on 12 April.

As expected due to the low thrips populations, there were only minor statistical differences among treatments in fruit scarring (Figure 2). None of the treatments contained fewer than 96% fancy grade fruit due to thrips scarring. Among the Surround WP treatments, volumes of 50, 250 and 150 gpa, and the standard, contained the greatest percentage of

fancy fruit and did not significantly differ among each other. The untreated contained the lowest percentage of fancy fruit, averaging 96.75%, but did not statistically differ from Surround WP at 100 gpa or the standard. These minor difference are probably only artifacts in the data and do not represent true differences.

Although the thrips populations were low, there did not appear to be any effect on thrips control due to spray volume. Additionally, visually one could not discern which plots were treated with 50, 100, 150, or 250 gpa. These data suggest that as long as the spray coverage of Surround WP visually appears to be adequate, that it is regardless of the spray volume used.

There was no significant effect of treatment upon total yield (data not shown)., however no conclusions can be drawn from the yield data since the first harvest data was lost.

Application of Surround WP led to minimal increases in fruit size for the 9/25/01 harvest (Table 1). Fruit size 140 was significantly greater when Surround WP was applied in 150 gpa spray volume, compared to untreated control and the commercial standard treatment. Other treatments (50 gpa, 100 gpa and 250 gpa) were intermediate and not significantly different than the others. This fruit size increase, and non-significant increases in fruit size 115 for trees sprayed with Surround WP in 150 gpa also led to significant increases in total fruit larger than size 140, compared to the untreated control. Conversely, fruit size 200 was significantly greater in the untreated control and standard, compared to all the Surround WP treatments.

Spray timing also led to improved fruit size in the 9/25/01 harvest (Table 2). Fruit size 115 was significantly greater when Surround WP was applied in March and April, compared to the untreated control. For size 115 fruit, the other two treatments were intermediate, and not different than the others. There were also non-significant trends to suggest that April and May treatments led to more fruit in the size 75, 95, and 140 size categories. These increases for trees sprayed with Surround WP in March and April also led to significant increases in all fruit larger than size 140, compared to the untreated control. Spring and Summer applications led to significant increase in fruit size 165, compared to the commercial standard. There were no effects of treatment upon fruit size categories.

For the second harvest, the majority of the fruit were found in the 140 size category, and at least 75% of the fruit harvested were size 140 or larger (Tables 3 and 4). Since there was some improvement in fruit size for the trees treated with Surround WP in the first harvest, and presumably more fruit were harvested from those trees, it is not surprising that in some cases, for the second harvest, trees with smaller fruit, which had been harvested less, had generally greater fruit size. The commercial standard treatment had significantly larger fruit size than Surround WP at 150 gpa and 250 gpa for fruit size 115, and larger fruit size than Surround WP at 100 gpa for fruit sizes greater than 140. Also, the untreated control had significantly more fruit of size 95 than did the trees that were sprayed in March, April and July. There was no effect of Surround application upon fruit size for the third harvest (data not shown).

It has been suggested that yield and fruit size increases attributable to Surround WP applications are due to leaf and fruit cooling. Lower leaf and fruit temperatures would increase net photosynthesis since stomates would remain open later into the day, allowing gas exchange to occur. Also, cooler leaves and fruit would respire less. Both increased gas exchange and reduced respiration may lead to a higher level of carbohydrates available for fruit growth. Higher levels of carbohydrates when fruit are small, might lead to less fruit drop; competition for carbohydrates limits the population of small fruit that can remain on a tree. Improved yield of trees treated with Surround WP would indicate an effect on small fruit during the Spring. It is unfortunate that such data was lost.

Higher levels of carbohydrates due to Surround WP applications when fruits are past the June drop would lead to larger fruit size, as shown here. Once the small fruits pass the possibility of abscission, they typically grow exponentially. The rate of that growth is determined by tree carbohydrate level. Our data suggest some improvement in fruit size, which may be due to improved carbohydrate levels in the tree.

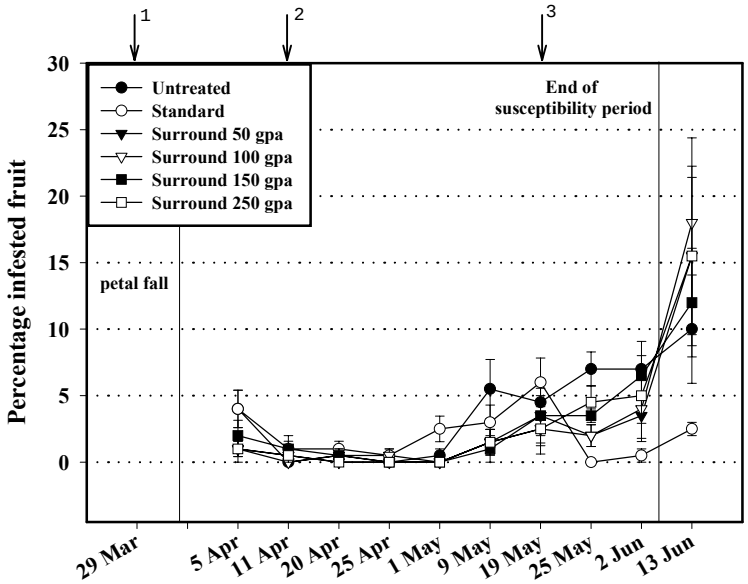

Figure 1. Percentages of lemon fruit infested with at least one immature citrus thrips. Applications 1 and 2 included all of the Surround WP treatments applied on 29 March and 12 April. Application 3 included only the standard which was Carzol SP at 1.0 lb/ac.

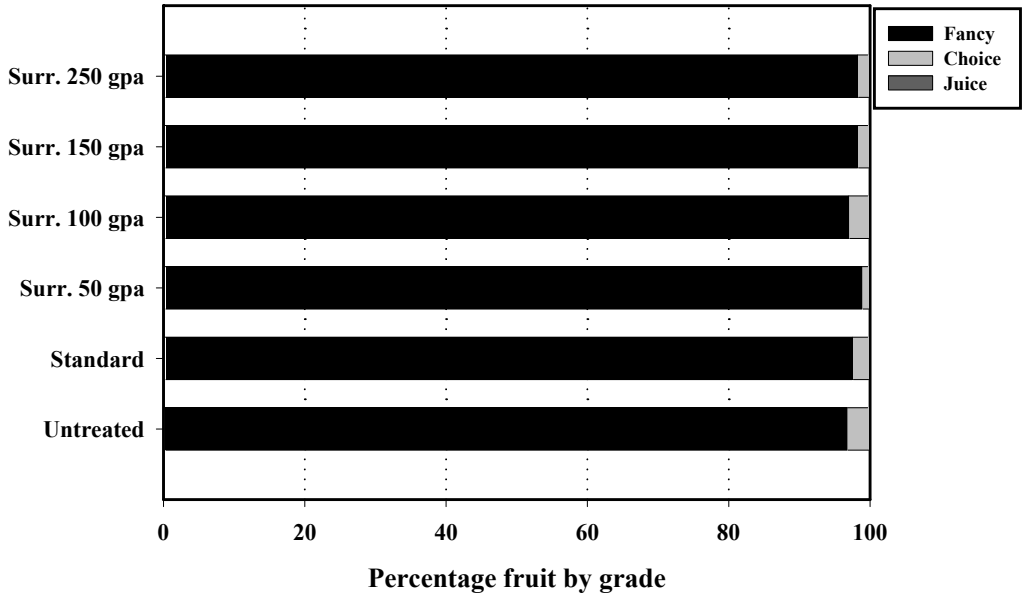

Figure 2. Percentage of fancy, choice and juice grade lemons due to thrips scarring.

Table 1. Effect of Surround spray gallonage on fruit size (packout) of lemon fruit harvested on 9-25-2000.

	Fruit Size (%)								
Gallonage	**63**	**75**	**95**	**115**	**140**	**165**	**200**	**235**	**140 or larger**
Surround @ 50 gpa	0.00 a[z]	0.00 a	0.60 a	5.67 a	37.11 ab	41.77 a	14.45 bc	0.38 a	43.38 ab
Surround @ 100 gpa	0.00 a	0.08 a	1.81 a	7.36 a	38.75 ab	39.84 a	12.00 bc	0.14 a	48.00 ab
Surround @ 150 gpa	0.00 a	0.08 a	1.09 a	7.54 a	42.61 a	38.81 a	9.82 c	0.03 a	51.32 a
Surround @ 250 gpa	0.00 a	0.09 a	1.30 a	5.42 a	36.51 ab	40.92 a	15.54 ab	0.19 a	43.32 ab
Spring Commercial Standard @ 100 gpa	0.00 a	0.00 a	1.03 a	5.68 a	34.40 b	36.98 a	20.58 a	1.34 a	41.10 ab
Untreated Control	0.00 a	0.00 a	0.69 a	4.65 a	33.06 b	40.02 a	21.08 a	0.49 a	38.40 b

[z]Means separation within columns by the Waller-Duncan t test, with a Type I to Type II error ratio of 75%.

Table 2. Effect of Surround spray application timing on fruit size (packout) of lemon fruit harvested on 9-25-2000.

	Fruit Size (%)								
Application Timing	**63**	**75**	**95**	**115**	**140**	**165**	**200**	**235**	**140 or larger**
29 March and 12 April	0.00 a[z]	0.08 a	1.57 a	8.10 a	40.39 a	37.90 ab	11.77 a	0.17 a	50.14 a
29 March, 12 April and 21 July	0.00 a	0.04 a	0.88 a	5.14 ab	37.45 a	42.46 a	13.82 a	0.20 a	43.50 ab
Spring Commercial standard	0.00 a	0.00 a	1.03 a	5.68 ab	34.40 a	36.98 b	20.59 a	1.34 a	41.10 ab
Untreated control	0.00 a	0.00 a	0.69 a	4.65 b	33.06 a	40.03 ab	21.09 a	0.49 a	38.40 b

[z]Means separation within columns by the Waller-Duncan t test, with a Type I to Type II error ratio of 75%.

Table 3. Effect of Surround spray gallonage on fruit size (packout) of lemon fruit harvested on 11-15-2000.

	Fruit Size (%)								
Gallonage	**63**	**75**	**95**	**115**	**140**	**165**	**200**	**235**	**140 or larger**
Surround @ 50 gpa	0.00 a[z]	0.56 a	9.37 a	18.56 abc	49.60 abc	18.78 ab	2.99 a	0.14 ab	78.10 bc
Surround @ 100 gpa	0.08 a	0.51 a	10.98 a	21.09 ab	47.43 bc	16.34 b	3.66 a	0.10 ab	79.90 ab
Surround @ 150 gpa	0.04 a	0.40 a	8.28 a	18.31 bc	48.28 abc	20.21 a	4.27 a	0.20 a	75.32 c
Surround @ 250 gpa	0.04 a	0.49 a	8.99 a	18.18 c	51.58 a	18.13 ab	2.56 a	0.04 b	79.27 ab
Spring Commercial Standard @ 100 gpa	0.00 a	0.48 a	9.30 a	21.31 a	50.98 ab	16.13 b	1.73 a	0.05 ab	82.07 a
Untreated Control	0.00 a	0.72 a	11.47 a	19.92 abc	47.11 c	17.80 ab	2.91 a	0.08 ab	79.22 ab

[z]Means separation within columns by the Waller-Duncan t test, with a Type I to Type II error ratio of 75%.

Table 4. Effect of Surround spray application timing on fruit size (packout) of lemon fruit harvested on 11-15-2000.

	Fruit Size (%)								
Application Timing	**63**	**75**	**95**	**115**	**140**	**165**	**200**	**235**	**140 or larger**
29 March and 12 April	0.02 a[z]	0.61 a	10.52 ab	20.50 a	47.80 bc	16.96 b	3.43 a	0.16 a	79.46 ab
29 March, 12 April and 21 July	0.06 a	0.37 a	8.20 b	17.57 b	50.64 ab	19.77 a	3.32 a	0.08 a	76.84 b
Spring Commercial standard	0.00 a	0.48 a	9.30 ab	21.31 a	50.98 a	16.12 b	1.73 a	0.05 a	82.07 a
Untreated control	0.00 a	0.72 a	11.47 a	19.92 a	47.11 c	17.80 ab	2.91 a	0.08 a	79.22 ab

[z]Means separation within columns by the Waller-Duncan t test, with a Type I to Type II error ratio of 75%.