

EVALUATION OF PYRETHRINS PLUS SILICA DIOXIDE TREATMENTS FOR RED IMPORTED FIRE ANT CONTROL

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Organic Plus™ Fire Ant Killer and Organic Solutions™ Multipurpose Fire Ant Killer (originally evaluated using Permaguard™ D-21) are dust formulations containing pyrethrins (0.2%, 0.1%), piperonyl butoxide (1.1%, 1.0%) and diatomaceous earth (97.9%) or silica dioxide (83.3). Pyrethrins are extracted from pyrethrum daisies, piperonyl butoxide is a synthetic synergist and silicone dioxide is the chemical composing the bodies of fossilized diatoms found in diatomaceous earth. These products are registered by the Environmental Protection Agency for treatment of the red imported fire ant, *Solenopsis invicta* Buren (Hymenoptera: Formicidae). We conducted a series of trials to evaluate these products and others considered to be 'organic'(Bonide® Rotenone 5 Insecticide, Insecto™ Formula 7, Natural Guard™ Nicotine Sulfate, Gardenville® Diatomaceous Earth), comparing efficacy to standard treatments including acephate (Valent™ Orthene® Turf, Tree & Ornamental Spray, Orthene® Systemic Insect Control), chlorpyrifos (Ortho-Klor® Soil Insect and Termite Killer) or diazinon (Rigo's Best Diazinon® 2E), water only treatment and untreated controls.

Materials and methods

Trial 1. Plots, 40 ft. wide and variable in length, containing 10 active fire ant mounds each, were established in ornamental turf in Brazos County, 12 May 1993. Plots were arrayed by length and blocked into four sets of eight plots each. Treatments listed below were randomly assigned to each of four blocks and applied to individually flagged mounds according to directions, 14 May.

<u>Treatment</u>	<u>Rate</u>
1. Organics Plus™ (0.2% pyrethrins + 1.1% piperonyl butoxide + 90% diatomaceous earth)	4 tbsp./1 gal./mound
2. Insecto™ Formula 7 (pine oil + sugar + linseed oil + mint oil + ammonium + coloring + water)	3 oz./3 gal./mound
3. Bonide® Rotenone 5 Insecticide (5% rotenone + 10% other cube resins)	1 rounded tbsp./2 gals. applied in 4 ft. diam. around mound
4. Natural Guard™ Nicotine Sulfate (10% nicotine (alkaloid))	1 tbsp./1 gal./mound
5. GardenVille® Diatomaceous Earth	4 tbsp./gal./mound
6. Orthene® Turf, Tree & Ornamental Spray (75% acephate dust)	1 tbsp./gal./mound
7. water drench	1 gal./mound
8. untreated check	dry

Two hours following completion of treatments (5:30 pm), one plot from each treatment except for Orthene® Turf, Tree and Ornamental Spray was inspected for ant activity in the ten mounds treated. At 3, 7, 14 and 30 days following treatment, plots were evaluated using the minimal disturbance method. Mounds were considered "active" (harbor an active ant colony) if a dozen or more ants emerged from the lightly disturbed mound and displayed defensive behavior, a method similar to that used by Frankem, 1983. New mounds occurring in each plot were also noted. Notes were also taken on any phytotoxicity which occurred as a result of the treatment. Post-treatment fire ant activity was analyzed based on the number of treated mounds and the total number of mounds per treatment plot using analysis of variance (ANOVA) and the Tukey's Studentized Range Test ($P \leq 0.05$) (PC SAS). Percent control was calculated from a pre-treatments level of 10 mounds.

Trial 2. Six treatments were evaluated to reduce the number of red imported fire ant mounds in treated areas. Treatments included:

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- 1) PermaGuard™, D-20 (0.2 % pyrethrins, 1% piperonyl butoxide plus diatomaceous earth) - 4 tbsp./gal./mound
NOTE: Quanta Lab (9330 Corporate Dr. #703, Selma, TX 78154-1257; 210/651-5799; FAX: 210/651-9271) analysis of this material documented 0.1% pyrethrins plus 0.9% piperonyl butoxide (Report #950S1004, 26 April 1995).
 - 2) PermaGuard™ D-21 (0.1 % pyrethrins, 1% piperonyl butoxide plus diatomaceous earth)- 4 tbsp./gal./mound
NOTE: Quanta Lab analysis of this material documented 0.1% pyrethrins plus 0.6% piperonyl butoxide (Report #950S1003, 26 April 1995).
 - 3) Ortho-Klor® Soil Insect and Termite Killer (12.8% chlorpyrifos) - 2 tbsp./gal./mound
 - 4) Orthene® Systemic Insect Control (9.4% acephate liquid) - 2 tbsp./gal./mound
 - 5) Untreated control - 1 gal. water per mound
 - 6) Permaguard D-20 applied with a Ortho® Dial'n Spray Hose-End Sprayer driven by a Shurflo® Diaphragm Pump powered by a 12 volt battery that delivers 40 psi. calibrated to deliver 2 lbs. Permaguard® in 50 gal. water per acre after spraying each mound within the treated area using an inward spiral spray pattern until the mound structure collapsed.
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Four sets of replicated plots of equal width and variable length, containing ten (10) red imported fire ant mounds were established for each treatment (40 mounds treated per treatment). Treatment blocks were assigned by arraying plot length from longest to shortest and treatments were randomly assigned within each block. Each mound was marked with a plot flag and received one of the six treatments. Periodically (3, 7, 14 and 31 days; on 6, 10, 17 Feb. and 6 March, respectively) following treatment, treated mounds and plots were inspected for ant activity using the minimal disturbance method. Results were analyzed using Analysis Of Variance (ANOVA) and means separated using Tukey's Studentized Range Test ($P \leq 0.05$).

Trial 3. Products evaluated in this trial are labeled to treat fire ant infested areas in sites listed using the methods listed below:

<u>Treatment</u>	<u>Method and rate appearing on product label</u>
1) Organic Solutions™ Multipurpose Fire Ant Killer (0.1% pyrethrins; 1.0% piperonyl butoxide, silicon dioxide 83.3%)	<p>As a dust: For best results, dust the perimeter of the mound first. With a stick, disturb the mound, then dust mound in a circular motion working toward the center until the entire mound is thoroughly dusted.</p> <p>Mound drench or "Water Method": Use 0.6 oz. (4 Tablespoons) to one gallon of water. For best results, saturate the perimeter of the mound first working toward the center of the mound in a circular motion (you may want the mixture to puddle). An ant mound 12-14 inches in diameter requires about one gallon of the mix.</p> <p>Hose-end sprayer: Use 16 oz. (1 lb.) per 1000 square feet of area. Use of a hose-end sprayer for lawns, add a small amount of water to the jar and add the amount needed for the measured area, stir to make a slurry, then add the remaining water to the top of the jar. Empty entire contents of the jar on the premeasured area.</p>
2) Valent™ Orthene® Turf, Tree & Ornamental Spray (acephate 75%)	2 teaspoons/mound
3) Rigo's Best Diazinon® 2E (diazinon 25.0%)	1 fl. oz. in 3 gals. of water/125 sq. ft. Spot spray ant hills

Twenty four plots were established in a shredded wayside area 22 to 44 feet wide and varying in length as to contain ten red imported fire ant mounds each. Fire ants in this location were assumed to be of the multiple queen (polygyne) form. Each mound was marked with a colored plot flag. Plots were arrayed from longest to shortest and divided into four blocks or replicates. Each of six treatments listed below were randomly assigned, one to each block.

<u>Treatments</u>	<u>Rate</u>
1) untreated control	---
2) Organic Solutions™ Multipurpose Fire Ant Killer:	
mound drench	4 tbsp./gal./mound
dust treatment	2 tbsp./mound
broadcast spray	4 tbsp./gal./thorough coverage of mounds & plot (1.77 oz./0.89 gal./mound + 14 oz./7.0 gal./1,000 sq. ft.)
3) diazinon 2E broadcast	8 fl. oz./24 gal./1,000 sq. ft.
4) acephate 75% WP	2 tsp./mound

All treatments were applied, August 17, 1995. Recent light rains had occurred and soil was moist. However, temperatures were in the 90 to 100 degree F range throughout much of this trial period. Casey Cornwell, a technical representative from Organic Solutions was present to apply the broadcast treatment of the Multipurpose Fire Ant Killer using a hydraulic sprayer provided by Organic Solutions. Volume of solution and amount of product used was measured by timing

treatments and determining flow rate. To treat individual ant mounds in broadcast treatment plots, 1.77 oz. Organic Solutions was used per mound (10 mounds treated) in 0.89 gal. water. Then the plots were oversprayed using 14.0 oz Organic Solutions per 1,000 sq. ft. in 7.0 gal. water. Diazinon was applied with a hose-end sprayer powered by a battery powered Shurflo RV Automatic Demand Pump, drawing diluted insecticide from a 40 gallon plastic container. Additional mounds detected during treatment were treated and marked with contrasting color flags so that they would not be included in subsequent monitoring efforts.

Periodically (4, 7, 14, 27 days) following treatment, marked mounds were inspected for ant activity using the minimal disturbance method. After the last evaluation, the plots were mowed to a height of 4 inches. Two days thereafter (Sept. 15), all active fire ant mounds were counted within each plot. Results were analyzed using analysis of variance (ANOVA) and means were separated using Tukey's Studentized Range test ($P \leq 0.05$).

Results and Discussion

The "strip plot" or "railroad track" method. The experimental design employed in these trials was developed to provide two types of efficacy data: 1) the effect of a treatment as measured by ant activity on four uniform sets (plots) of 10 marked red imported fire ant mounds; and 2) the ability of individual mound treatments to reduce the total number of ant mounds in treated areas. By arraying plot length to produce blocks within which treatments are randomly assigned, the mean plot length for each treatment becomes uniform (**Table 1**). In this way, the probability of fire ant colonies migrating in or out of any given set of treatment plots is equal. Furthermore, the presence of a number of 'new' (unmarked) mounds which appeared between treatment plots were considered to be relocated fire ant colonies, called 'satellite' mounds. These were separately documented and included in evaluations. This method is considered to be an improvement over previous methods used (Franke 1983) because it addresses the issue of colony relocation following treatment.

Trial 1. Of the 'organic' treatments tested, Organics Plus™ Fire Ant Killer caused the most rapid reduction in ant activity. The number of active mounds of ten treated was: Organics Plus™ - 2; Insecto™ Formula 7 - 10; Bonide® Rotenone 5 Insecticide - 9; Natural Guard™ Nicotine Sulfate - 10; GardenVille® Diatomaceous Earth - 9; water drench - 10; and untreated check - 9. Fire ant activity in mounds following treatments is presented in **Table 2**. Organics Plus™ and Orthene® Turf, Tree and Ornamental Spray treatments resulted in statistically similar reductions of ant activity. These treatments produced a rapid, 80 to 85 percent, elimination of ant activity in treated mounds within 3 days of treatment. Percent control continued to increase, reaching 95 to 98 percent at 14 and 30 days following treatment, respectively. Insecto™ Formula 7 drenches resulted in a slow decline in ant activity. Natural Guard™ Nicotine Sulfate and Gardenville® Diatomaceous Earth treatments produced no significant reductions of red imported fire ant mound numbers throughout this trial. Gardenville® Diatomaceous Earth is not an EPA registered insecticide for fire ant control. Plots treated with Orthene® and the untreated control had fewer 'satellite' mounds recorded following treatment than other treatments. No phytotoxicity was observed.

Trial 2. The average plot size was 750 sq. ft. On the day of treatment, the temperature ranged from 64.5 to 68.2 degrees F and relative humidity from 50 to 43 percent. Individual mound drenches of flagged mounds required about 2.4 man-minutes per mound (\$0.17 per mound at minimum wage of \$4.25 per hour). Per mound cost for treatments was \$0.48/mound for Orthene® Systemic Insect Control and \$0.55/mound for Ortho-Klor® Soil Insect & Termite Killer.

Ten ounces of Permaguard® were mixed per gallon of water and used to fill the sprayer. The Ortho® Dial'n Spray Hose-End Sprayer, set at 8 oz rate, emitted 1.62 gal water/minute and sprayed out 13.5 fl oz dissolved insecticide per minute. Permaguard™ was dispensed at 0.0176 oz per minute. The amount of spray used on the hose-end treated plots is listed below:

<u>Plot no./length</u>	<u>Spray time/plot</u>	<u>Spray time/10 mounds</u>	<u>Total amount</u>
6 15 ft	19 sec. (4.3 fl. oz.)	80 sec. (18 fl. oz)	= 1.74 oz. Permaguard® D-20
7 46 ft	59 sec. (13.3)	69 sec. (15.5)	= 2.25 oz.
23 24 ft	31 sec. (7.0)	56 sec. (12.6)	= 1.53 oz.
24 18.5 ft	24 sec. (5.4)	85 sec. (5.4)	= 1.91 oz.

Four tablespoons of Permaguard™ D-20 weighs 22.2 grams or 0.78 oz. Plots receiving individual mound drenches for 10 mounds received 7.8 oz. product.

The Permaguard® formulations performed differently, with D-20 (0.2% pyrethrins, 1% piperonyl butoxide plus diatomaceous earth) providing significantly better elimination of ant activity than D-21 (0.1% pyrethrins) 3 days following application (**Table 3**). Permaguard™ D-20, applied as an individual mound treatment eliminated ant activity in treated mounds more quickly than did Orthene® Systemic Insect Control (9.4% acephate), and performed statistically similar to Ortho-Klor® Soil Insect and Termite Killer (12.8% chlorpyrifos) throughout the trial. From 1 to 4 weeks following application, all individual mound treatments significantly reduced ant activity in treated mounds relative to ant activity in untreated control (water drench only) mounds and performed statistically the same, providing 75 to 100 percent suppression of ant activity in treated mounds.

The surface application of Permaguard™ D-20 significantly reduced the number of ant mounds 1 to 4 weeks following treatment relative to the untreated control (water drench only) plots by 50 to 53 percent. Apparently, the "spiral pattern spray" to individual mounds failed to deliver sufficient product to eliminate ant activity in treated mounds to the extent that 1 gallon individual mound treatments achieved. However, less material was applied to the plots using the surface treatment (1.9 oz. versus 7.8 oz for individual mound treated plots). (Note: The individual mound treatment rate of PermaGuard™ would have resulted in the application of 28.3 lbs. per acre for 581 ant mound infestation in this study area. Obviously, in areas with fewer mounds per acre would require less material.)

None of the treatments applied appeared to greatly aggravate colony movement (**Table 4**), although more "new" colonies appeared in the plots treated with the surface application of

PermaGuard™ D-20. However, new mounds appeared in the plots during the course of this 4 week long trial. By the fourth week, only the Ortho-Klor® Soil Insecticide and Termite Killer (chlorpyrifos 12.8%) treated plots contained significantly fewer mounds than did the untreated control plots, having 65 percent fewer mounds. The other treatments performed statistically similar to Ortho-Klor® Soil Insecticide and Termite Killer, achieving percent reductions of active fire ant mounds ranging from 58 to 13 percent.

This trial was conducted in February, and was characterized by mild and wet climate conditions. Field plots were mowed 1 and 27 Feb. Conceivably, colony migration into mowed plots from adjacent high grass areas may have increased because of the mowings or because of natural ant behavior during this period of the year. Further testing with these treatments will provide additional confidence in the results generated from this trial.

Trial 3. All treatments significantly reduced the number of red imported fire ant mounds treated within 4 days except the dry dust treatment of Organic Plus Multipurpose Fire Ant Killer (**Table 5**). This treatment remained less effective than the rest even though periodic rain showers occurred during the monitoring period (Aug. 19, 23, Sept. 13) that were sufficiently heavy to dissolve most of the powdered insecticide into the soil. Thereafter, all except the dust treatment performed, providing 95 to 100 percent elimination of active ant mounds treated. The dust treatment did significantly reduce the number of active ant mounds 36 to 54 percent relative to the number in untreated plots, but not to the same degree as did the rest of the treatments.

New mounds occurring in treatment plots 29 days after treatment resulted either from 1) treated colonies moving away from treatment spots and forming a new "satellite" colony; 2) treated colonies moving away from treatment spots and forming more than one new ant mound, a process referred to as "shattering"; or 3) migration of colonies into the treatment plots from untreated adjacent areas. Organic Solutions Multipurpose Fire Ant Killer treatment plots were found to harbor as many or more new unmarked mounds at that time than those found in untreated plots (**Table 5**). Only the acephate and diazinon treated plots contained significantly fewer total ant mounds at the end of the trial than untreated plots, providing 69 and 98 percent suppression of mound numbers, respectively.

Acknowledgements

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Literature Cited

Franke, O. F. 1983. Efficacy tests of single-mound treatments for control of red imported fire ant, *Solenopsis invicta* Buren. Southwest Entomologist 8:42-45.

Table 1. Length of plots (feet and inches and total feet) containing 10 active Red Imported Fire Ant mounds each before treatment, Brazos Co., Texas 1993 (Trial 1).

<u>Treatment</u>	Block				<u>Total length</u>
	<u>I</u>	<u>II</u>	<u>III</u>	<u>IV</u>	
Organics Plus™	21' 1"	25' 9"	28' 4"	35' 6"	110.66
Insecto™ Formula 7	24' 0"	20' 0"	27' 6"	46' 8"	123.17
Bonide® Rotenone 5 Insecticide	23' 9"	26' 4"	27' 0"	56' 2"	133.25
Natural Guard™ Nicotine sulfate	26' 0"	34' 2"	34' 8"	38' 2"	133.01
Gardenville® Diatom- aceous Earth	20' 9"	24' 5"	32' 8"	37' 2"	115.01
Orthene® Turf, Tree and Ornamental Spray	20' 1"	24' 7"	29' 10"	46' 2"	122.65
water drench	21' 6"	26' 2"	27' 6"	38' 1"	113.25
untreated check	17' 4"	17' 10"	22' 5"	45' 5"	103.00

Table 2. Number of treated mounds of ten containing active Red Imported Fire Ant colonies following treatment using 'organic' insecticide products, Brazos Co., Texas, Trial 1, treated May 1993.

	Dates Post-treatment ¹			
	17 May <u>3 day</u>	21 May <u>7 day</u>	27 May <u>14 day</u>	11 June <u>30 day</u>
No. active fire ant mounds/10 (Percent control in parentheses)				
Organics Plus™	2.00b (80)	2.00d (80)	0.25b (98)	0.50b (95)
Insecto™ Formula 7	4.75b (53)	4.00bcd (60)	0.25b (98)	0.50b (95)
Bonide® Rotenone 5 Insecticide	4.50b (55)	3.25cd (68)	3.25b (68)	1.50b (85)
Natural Guard™ Nicotine sulfate	8.50a (15)	6.50abc (35)	7.75a (23)	6.50a (35)
Gardenville® Diatomaceous Earth	8.00a (20)	8.25ab (17)	8.25a (18)	6.75a (33)
Orthene® Turf and Ornamental Spray water drench	1.50b (85) 9.00a (10)	1.25d (88) 7.75ab (23)	0.25b (98) 8.00a (20)	0.25b (98) 6.25a (38)
untreated control	9.50a (5)	10.0a (0)	9.50a (5)	8.25a (18)
<i>F</i>	15.47	8.76	21.95	27.27
<i>P</i>	0.0001	0.0001	0.0001	0.0001
MSE	1.809	3.400	2.149	1.208
Min. Sig. Diff.	3.1904	4.3735	3.4767	2.6071
R-square	0.8805	0.8066	0.9126	0.9285
d.f. = 21; Studentized Range = 4.743				

¹ Mean no. fire ant active mounds/10 treated per plot. Means followed by the same letter are not significantly different according to ANOVA and the Tukey's Studentized Range Test ($P \leq 0.05$). Percent reduction of ant activity in mounds in parentheses.

Table 3. Mean number active ant mounds following application of individual red imported fire mound treatments, Brazos Co., Texas, Trial 2, treated 3 Feb. 1995.

<u>Treatment</u>	Mean no. active mounds/10^a			
	<u>3 days</u>	<u>1 week</u>	<u>2 week</u>	<u>4 weeks</u>
untreated control				
1 gal. water/mound	10.00 a...	10.00 a..	8.75 a..	9.25 a..
Permaguard™ D-21 (0.1% pyrethrins, 1% PBO)				
4 tbsp./gal./mound	6.00 .b..	2.50 .bc	1.25 ..c	2.00 .bc
Permaguard™ D-20 (0.2% pyrethrins, 1% PBO)				
4 tbsp./gal./mound	1.50 ..cd	0.25 ..c	0.25 ..c	1.00 ..c
Permaguard™ D-20 surface treatment ^b				
2 lbs./50 gal./acre	9.75 a...	4.75 .b.	4.75 .b.	5.00 .b.
Orthene® Systemic Insect Control (9.4% acephate EC)				
2 tbsp./gal./mound	4.00 .bc .	1.00 ..c	1.00 ..c	1.25 ..c
Ortho-Klor® Soil Insect and Termite Killer (12.8% chlorpyrifos)				
2 tbsp./gal./mound	0.00 ...d	0.00 ..c	0.00 ..c	0.00 ..c
<i>F</i>	22.32	30.40	17.80	13.12
<i>P</i>	0.0001	0.0001	0.0001	0.0001
MSE	1.952	1.200	1.7111	2.333
Min. Sig. diff.	3.2104	2.5166	3.0052	3.5093
d.f. = 15; Critical value = 4.595				

^a Means followed by the same letter are not significantly different using analysis of variance (ANOVA) and the Tukey's Studentized Range Test ($P \leq 0.05$).

^b Permaguard™ D-20 applied with a Ortho® Dial'n Spray Hose-End Sprayer driven by a Shurflo® Diaphragm Pump powered by a 12 volt battery that delivers 40 psi. to spray plot surface after spraying each mound within the treated area using an inward spiral spray pattern until the mound structure collapsed.

Table 4. Mean number of new mounds appearing per plot and total number of active ant mounds per plot following treatment of individual red imported fire ant mounds, Brazos Co., Texas, 1995.

<u>Treatment</u>	Mean no. active mounds/plot^a		No. "satellite" mounds/plot^a	
	<u>2 weeks</u>	<u>4 weeks</u>	<u>2 weeks</u>	<u>4 weeks</u>
untreated control	10.25 a..	11.50 a.	1.50 a	2.25 a
Permaguard™ D-21	2.75 .bc	7.25 ab	1.50 a	5.25 a
Permaguard™ D-20	1.00 ..c	4.25 ab	1.25 a	3.25 a
Permaguard™ D-20 surface treatment	7.50 ab.	8.75 ab	2.75 a	3.75 a
Orthene® Systemic Insect Control	2.25 .bc	5.00 ab	1.25 a	3.75 a
Ortho-Klor® Soil Insect and Termite Killer	0.50 ..c	3.50 .b	0.50 a	3.50 a
<i>F</i>	6.35	5.23	0.69	2.14
<i>P</i>	0.0011	0.0029	0.6934	0.0972
MSE	6.275	6.964	2.919	11.986
Min. Sig. diff.	5.755	6.0626	3.9254	7.9537
d.f. = 15; Critical value = 4.595				

^a Means followed by the same letter are not significantly different using analysis of variance (ANOVA) and the Tukey's Studentized Range Test ($P \leq 0.05$).

Table 5. Mean number of active red imported fire ant mounds per plot, with 10 mounds treated per plot in four replicated variable sized plots, Trial 3, treated 17 Aug. 1995, Burleson Co., Texas.

<u>Treatment and rate</u>	Mean no. fire ant mounds per plot/10 initially treated				Total mounds per plot (new)	
	<u>Aug 21</u> Day 4	<u>Aug 24</u> Day 7	<u>Aug 31</u> Day 14	<u>Sept 13</u> Day 27	<u>Sept 15</u>	
untreated check	9.8a*	9.3a	8.8a	7.5a	(8.8)	16.3a
Organic Solutions® dust treatment (2 tbsp./mound)	9.5a	5.5b	4.0b	4.8b	(16.8)	21.5a
mound drench (4 tbsp./gal./mound)	0.8b	0.5c	0.5c	0.3c	(13.0)	13.3a
broadcast spray (4 tbsp./gal./thorough coverage of plot)	0.0b	0.3c	0.3c	0.3c	(11.8)	12.0ab
acephate 75% WP (2 tsp./mound)	0.3b	0.0c	0.3c	0.0c	(5.0)	5.0bc
diazinon 2E broadcast (8 fl. oz./24 gal./ 1,000 sq. ft.)	0.3b	0.0c	0.0c	0.0c	(0.3)	0.3c
<i>F</i>	111.54	74.88	30.51	29.70		11.82
<i>P</i>	0.0001	0.0001	0.0001	0.0001		0.0001
MSD	1.6602	1.6424	2.3322	2.1761		10.259
d.f. = 8						

* Means in columns followed by the same letter are not significantly different using analysis of variance (ANOVA) and means were separated using Tukey's Studentized Range test ($P \leq 0.05$).