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Evaluation of Some Bactericides and Bactericide Mixtures for Suppression of Bacterial Diseases on Landscape Ornamental Plants

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Diseases of woody ornamental plants incited by bacteria occur sporadically during nursery production, but when they occur, they are difficult to control, so economic losses often result. Bacterial plant pathogens in the genera Xanthomonas and Pseudomonas probably cause the greatest losses, particularly in a humid climates such as Florida provides. Pseudomonas species. such as *P. syringae*, *P. chicorii*, and *P. marginalis* occur frequently and damage many nursery crops. Damage from Xanthomonas species, especially various pathovars of *X. campestris,* is especially common in warm, humid weather. At present, there are few options for control or suppression once these pathogens appear. Copper compounds and antibiotics provide mostly unsatisfactory results, especially in disease-favorable climates. Moreover, growers usually attempt to suppress or control bacterial plant pathogens after disease damage has appeared when control is particularly difficult.

This study evaluated some new products (and mixtures) with potential for suppression and control of plant pathogenic bacteria. Treatments were applied weekly because a previous test during the spring and summer of 2006 indicated that similar products applied at 14-day intervals did adequately suppress bacterial diseases or significantly reduce disease damage (Strandberg, 2006) . It is not feasible to test bactericides on numerous ornamental species, but the results obtained here are likely transportable to similar crops. Successful suppression or control (or lack of it) of four typical and representative pathogens (two *Pseudomonas* and two *Xanthomonas* spp.) on four representative species of woody ornamental plants were evaluated .

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MATERIALS AND METHODS

Two *Xanthomonas* spp. were evaluated on two representative woody ornamental plants: *Prunus umbellata* or *P. incisa x campanulata* cv. 'Okame' infected with *Xanthomonas campestris* pv *pruni*, and Wax myrtle (*Myrica cerifera* infected with a *Xanthomonas* species (currently being identified to species) respectively. Two species representative of the genus Pseudomonas: *Pseudomonas chicorii* and *P. marginalis* were evaluated on Hibiscus (*Hibiscus rosa-sinensis*), and Hydrangea (*Hydrangea quercifolia*) respectively. Also, an unknown Xanthomonas species (which is currently being identified) was isolated from some Hydrangea plants, so there was likely a mixed infection on this host.

Treatments were applied at 7-day intervals beginning on June 27 through September. Plants were quantitatively evaluated by periodic (7-day interval) leaf sampling and estimating percent leaves infected and percent leaf area damaged of the sampled leaves. The tests were done at the University of Florida, Mid-Florida Research and Education Center, Apopka, Florida.

There were four replicates for each treatment in a randomized complete block design. Plot size was 4 ft X 12 ft (0.0011 acre). Each plot contained 12 plants of each of the four species placed in adjacent closely-spaced rows. Plots were separated by at least six feet on all sides from adjacent plots.

Treatments were applied with a compressed air-powered sprayer maintained at 40 lb/in^2 pressure at the nozzle (TeeJet 8004 tip Spraying Systems Co, Wheaton, IL 60189) to deliver 50 gal/acre. Treatments and application rates are specified in Table 1. Test plants, originally growing in 1-gallon pots, were transplanted into 3-gallon pots by June 15 using a peat-sand-pine bark-compost potting mix with minor elements and dolomite. Osmocote fertilizer 19-6-12 was added twice during the test (30 g per pot). Plants were watered nightly with an automatic, overhead sprinkler irrigation system.

Moderate disease damage was present on Japanese Plum, Hydrangea, and Wax myrtle the beginning of the experiment; Hibiscus had minimal amounts of disease damage, therefore, Hibiscus plants were re-inoculated with bacteria cells produced in culture. Nutrient broth was inoculated with *P. chicorii,* and grown at 24 C for 24 hr with continuous shaking. Bacterial cells were then centrifuged, re-suspended in tap water, and sprayed on appropriate test plants early in the morning when plants were wet with dew and from irrigation.

Treatments were applied to all test plants at 7-day intervals. Plots were evaluated each week for disease incidence and damage by sampling 15 leaves at random from each replicate of each species throughout the experiment. Leaf samples were evaluated for percent of sampled leaves diseased and average percent leaf area damaged (LAD) using specially-prepared pictorial disease damage keys. For each sampling date, average percent LAD and the percent of leaves infected were calculated. Final results were determined by obtaining the average of the area under the disease progress curves (AUDPC). Data were analyzed with a 2-way ANOVA (block, treatment) and means were separated with Student-Newman-Keuls method. Results are provided as relative AUDPC for percent LAD and percent leaves infected (Tables 2 - 5). Percent LAD and percent leaves infected on the final sampling day were also analyzed (Tables 2 - 5). Because of the variation in data and the difficulty in interpreting it, the weekly results for LAD and percent infected leaves for each treatment were plotted along with data for the unsprayed control. These data are provided in Figures 1 - 4, A and B).

RESULTS AND DISCUSSION

Disease damage progressed normally on Japanese Plum, Hydrangea, and Wax Myrtle, but more slowly on Hibiscus after it was inoculated, so fewer sampling days were obtained for Hibiscus. However, there was sufficient disease damage to evaluate the products tested. on all four host species. A complicating issue was the periodic and production of new leaves that occurred throughout the experiment. Since the samples came from a particular sector of the plant's foliage; this sometimes had the apparent effect of greatly reducing LAD and percent infected leaves because of the dilution effect of the new and uninfected leaves that were collected at random. On the other hand, when a flush of new leaves became infected, and continuous new leaf production did not occur, this resulted in repeated collections of diseased leaves. Of the data collected, the area under disease progress curves provided the best information for determining efficacy. The plots of disease damage and percent of sampled leaves infected (compared with unsprayed controls) provided additional information for interpretation of the results.

None of the treatments were judged to adequately suppress any of the bacterial diseases studied. However, inspection of disease progress curves provided some indications of efficacy.

Xanthomonas campestris pv. *pruni* on Japanese Plum - Disease damage was severe. No treatment appeared to suppress disease incidence or severity (Figure1 A and B). Area under the disease progress curves indicated that some of the treatments might have increased disease incidence and damage, but this effect was not striking or consistent (Table 2) There were no significant differences between the final ratings (Table 2).

Xanthomonas species on Wax myrtle - Disease damage was severe. None of the treatments appeared to consistently reduce disease damage. However, Phyton New Dimension, Kasumin plus Kocide 3000, and Tricon appeared to have some effect in reducing the percent infected leaves (Figure 2 A and B). There were no significant differences between the area under the disease progress curves or the final ratings (Table 3).

Pseudomonas marginalis on Oak Leaf Hydrangea - Disease damage and icidence moderate to severe. Tanos plus Kocide 3000 Kasumin plus Kocide 3000, and Tricon appeared to reduce the severity of disease damage, but none of the treatments consistently reduced the percent of leaves infected (Figure 3 A and B). There were no significant differences among the disease progress curves or the final ratings (Table 4).

Pseudomonas chicorii on Hybiscus - Disease incidence and severity mas only slight to moderated on Hibiscus. Phyton New Dimension, Tricon, Kasumin plus Kocide 3000, K-Phite plus Tricon Tanos plus Kocide 3000, and Biophos plus chelated copper all appeared to somewhat reduce disease damage, although often not consistently. Kasumin plus Kocide 3000, Tricon, Biophos plus chelated copper and Kocide 3000 moderately reduced the percent of diseased leaves, although not always significantly or consistently (Figure 4 A and B). There were no significant differences between the area under the disease progress curves or the final ratings (Table 5).

No phytotoxicity was noted in this experiment.

The weather during this experiment was typical for the location except rain events were relatively more frequent than average. Coupled with nightly sprinkler irrigation, warm temperatures, and closely spaced plants, an environment very favorable for bacterial plant pathogens was created. Accordingly disease incidence and damage were severe. It is also difficult to sample and evaluate foliar diseases of woody ornamentals. Fluctuations in foliage growth followed by relatively dormant periods resulted in data that are quite variable as shown in Tables 2 through 4. However, inspection of the plots of sampling data indicates that some of treatments had some beneficial effects and might be useful where conditions are less favorable for disease.

Strandberg, J. O. 2006. Evaluation of Some Bactericides and Biopesticides for Suppression of Bacterial Diseases on Landscape Ornamental Plants. University of Florida, IFAS, MREC Apopka, Plant Pathology Research Report 2006 - 2, October, 2006. 12 P.

Available at:

http://mrec.ifas.ufl.edu/jos/IR4%20Woody%20Ornamental%20Report.pdf

Table 1. Treatments and application rates evaluated for control of bacterial disease on four woody ornamental species at Apopka, Florida, Summer, 2007.

Product	Application Rate	
Phyton New Dimension	25 oz/100 gal/A	Copper pentahydrate
Kasumin + Kocide 3000	64oz/50 gal/A 2 lb/ 100 gal/A	Kasugamycin (2%) Copper Hydroxide
Tricon	0.8 %	Sodium borate decahydrate
K-Phite + Tricon	2qts / 100 gal /A 0.4 %	Phosphorous acid Sodium borate decahydrate
Tricon (alternated with) Phyton New Dimension	0.8 % 25 oz/100 gal/Al	Sodium borate decahydrate Copper pentahydrate
BioPhos + Chelated copper	2% 0.1 lb ai Cu	Phosphorous acid Chelated copper
Tanos + Kocide 3000	8 oz/100 gal/A 2 lb/100 gal/A	Famoxadone (25%) + Cymoxanil (25%) Copper hydroxide
Kocide 3000	2 lb/ 100 gal/A	Copper hydroxide
Control	------	--------

[1] All rates were re-calculated for application in 50 gal/acre of water per acre in this experiment.

Table 2. Summary of data for Japanese Plum *(Prunus incisa x campanulata* cv Okame) plants infected with *Xanthomonas campestris* pv. *pruni* following application of some bactericides at 7-day intervals at Apopka, Florida, Summer and Fall, 2007.

Product	AUDPC [1] Percent LAD	Last [2] Percent LAD	AUDPC [3] Percent Infected	Last [4] % leaves Infected
Phyton New Dimension	4350.6 a	31.86	4877.8 b	88.33
Kasumin + Kocide 3000	4278.7 a	7.20	3915.3 a b	70.00
Tricon	4105.4 a	24.00	3977.1 a b	91.67
K-Phite + Tricon	4182.2 a	18.12	4683.7 a b	88.33
Tricon (alternated with) Phyton New Dimension	5174.9 b	24.28	3968.3 a b	95.00
BioPhos + Chelated copper	5105.9 b	8.50	4111.5 a b	78.33
Tanos + Kocide 3000	3957.6 a	11.38	4353.7 a b	66.67
Kocide 3000	4211 4 a	14.76	3939.5 a b	80.00
Control	4550.9 a	12.47	3644.7 a	81.67
F =	7.911	1.824 NS	2.988	1.525 NS
P =	0.000	0.122	0.018	0.201

[1] Calculated mean area under the disease progress curves in arbitrary units for percent leaf area damaged. Value is average for four replications. Means separated by Student-Newman-Keuls method based upon 2-way analysis of variance. Values followed by the same letter are not significantly different at the *P* = 0.05 level.

[2] Percent LAD on last sampling day. Value is average for four replications. Means separated by Student-Newman-Keuls method based upon 2-way analysis of variance of Arc Sin of percentage values. Values followed by the same letter are not significantly different at the *P* = 0.05 level.

[3] Calculated mean area under the disease progress curves in arbitrary units for percent of leaves infected. Value is average for four replications. Means separated by Student-Newman-Keuls method based upon 2-way analysis of variance. NS = not significant at P = 0.05 level.

[4] Percent of leaves infected on last sampling day. Value is average for four replications. Means separated by Student-Newman-Keuls method based upon 2-way analysis of variance of Arc Sin of percentage values. NS = not significant at P = 0.05 level.

Table 3. Summary of data for Wax Myrtle (*Myrica cerifera)* plants infected with *a Xanthomonas* spp. following application of some bactericides at 7-day intervals at Apopka, Florida, Summer and Fall, 2007.

Product	AUDPC [1] Percent LAD	Last [2] Percent LAD	AUDPC [3] Percent Infected	Last [4] % leaves Infected
Phyton New Dimension	2957.1	2.62	3298.6	45.00
Kasumin + Kocide 3000	2844.0	2.07	3038.9	40.00
Tricon	2946.6	3.05	3357.7	45.00
K-Phite + Tricon	2946.6	2.37	3566.3	51.67
Tricon (alternated with) Phyton New Dimension	3133.5	5.65	3521.3	53.33
BioPhos + Chelated copper	2963.8	2.38	3077.5	40.00
Tanos + Kocide 3000	2986.0	2.28	3156.7	41.67
Kocide 3000	3112.1	1.68	3065.7	31.67
Control	3304.3	4.23	3278.6	46.67
F=	1.291 NS	1.445 NS	1.245 NS	0.873 NS
P=	0.294	0.225	0.317	0.552

[1] Calculated mean area under the disease progress curves in arbitrary units for percent leaf area damaged. Value is average for four replications. Means separated by Student-Newman-Keuls method based upon 2-way analysis of variance. NS = not significant at P = 0.05 level.

[2] Percent LAD on last sampling day. Value is average for four replications. Means separated by Student-Newman-Keuls method based upon 2-way analysis of variance of Arc Sin of percentage values. NS = not significant at P = 0.05 level..

[3] Calculated mean area under the disease progress curves in arbitrary units for percent of leaves infected. Value is average for four replications. Means separated by Student-Newman-Keuls method based upon 2-way analysis of variance of ArcSin of percentage values. Values followed by the same letter are not significantly different at the P = 0.05 level.

[4] Percent of leaves infected on last sampling day. Value is average for four replications. Means separated by Student-Newman-Keuls method based upon 2-way analysis of variance of ArcSin of percentage values. NS = not significant at P = 0.05 level.

Table 4. Summary of data for Oak Leaf Hydrangea *(Hydrangea quercifolia*) plants infected with *Pseudomonas chicorii* and an unknown *Xanthomonas* spp following application of some bactericides at 7-day intervals at Apopka, Florida, Summer and Fall, 2007.

Product	AUDPC [1] Percent LAD	Last [2] Percent LAD	AUDPC [3] Percent Infected	Last [4] % leaves Infected
Phyton New Dimension	257.83	3.22	222.31	55.0
Kasumin + Kocide 3000	225.28	2.7833	168.92	55.0
Tricon	196.76	1.72	188.79	46.7
K-Phite + Tricon	255.55	3.59	194.21	56.7
Tricon (alternated with) Phyton New Dimension	244.89	3.55	250.35	61.7
BioPhos + Chelated copper	218.05	3.38	179.04	63.3
Tanos + Kocide 3000	210.67	2.7107	168.38	53.8
Kocide 3000	228.06	2.83	204.69	50.0
Control	231.78	3.37	239.91	58.3
F	21.70 NS	0.509 NS	1.982 NS	0.739 NS
P	0.68	0.206	0.093	0.657

[1] Calculated relative mean area under the disease progress curves in arbitrary units for percent leaf area damaged. Value is average for four replications. Means separated by Student-Newman-Keuls method based upon 2-way analysis of variance. Values followed by the same letter are not significantly different at the *P* = 0.05 level.

[2] Percent LAD on last sampling day. Value is average for four replications. Means separated by Student-Newman-Keuls method based upon 2-way analysis of variance of the Arc SIn of percentage values. NS = not significant at *P* = 0.05 level..

[3] Calculated relative mean area under the disease progress curves in arbitrary units for percent of leaves infected. Value is average for four replications. Means separated by Student-Newman-Keuls method based upon 2-way analysis of variance. Values followed by the same letter are not significantly different at the *P* = 0.05 level.

[4]Percent of leaves infected on last sampling day. Value is average for four replications. Means separated by Student-Newman-Keuls method based upon 2-way analysis of variance of the Arc Sin of percentage values. NS = not significant at *P* = 0.05 level..

Table 5. Summary of data for Hibiscus *(Hibiscus rosa-sinensis*) plants infected with *Pseudomonas chicorii* following application of some bactericides at 7-day intervals at Apopka, Florida, Summer and Fall, 2007.

Product	AUDPC [1] Percent LAD	Last [2] Percent LAD	AUDPC [3] Percent Infected	Last [4] % leaves Infected
Phyton New Dimension	18.72 a b	0.93	35.73 ab	0.15
Kasumin + Kocide 3000	6.02 a	0.20	22.68 ab	0.07
Tricon	14.06 a b	0.37	28.08 ab	0.10
K-Phite + Tricon	29.98 a b	0.75	19.37 ab	0.12
Tricon (alternated with) Phyton New Dimension	33.02 a b	0.25	14.91 a	0.05
BioPhos + Chelated copper	31.84 a b	0.38	20.40 ab	0.12
Tanos + Kocide 3000	30.94 a b	0.67	40.55 ab	0.10
Kocide 3000	22.34 a b	0.35	28.54 ab	0.08
Control	39.62 b	1.07	40.13 b	0.20
F =	3.020	1.491 NS	3.340	1.747 NS
P =	0.013	0.242	0.010	0.139

1 Calculated mean area under the disease progress curves in arbitrary units for percent leaf area damaged. Value is average for four replications. Means separated by Student-Newman-Keuls method based upon 2-way analysis of variance. Values followed by the same letter are not significantly different at the *P* = 0.05 level.

[2] Percent LAD on last sampling day. Value is average for four replications. Means separated by Student-Newman-Keuls method based upon 2-way analysis of variance of Arc Sin of percentage values. NS = not significant at *P* = 0.05 level.

[3] Calculated mean area under the disease progress curves in arbitrary units for percent of leaves infected. Value is average for four replications. Means separated by Student-Newman-Keuls method based upon 2-way analysis of variance. NS = not significant at *P* = 0.05 level.

[4] Percent of leaves infected on last sampling day. Value is average for four replications. Means separated by Student-Newman-Keuls method based upon 2-way analysis of variance of ArcSin of percentage values. NS = not significant at P = 0.05 level.

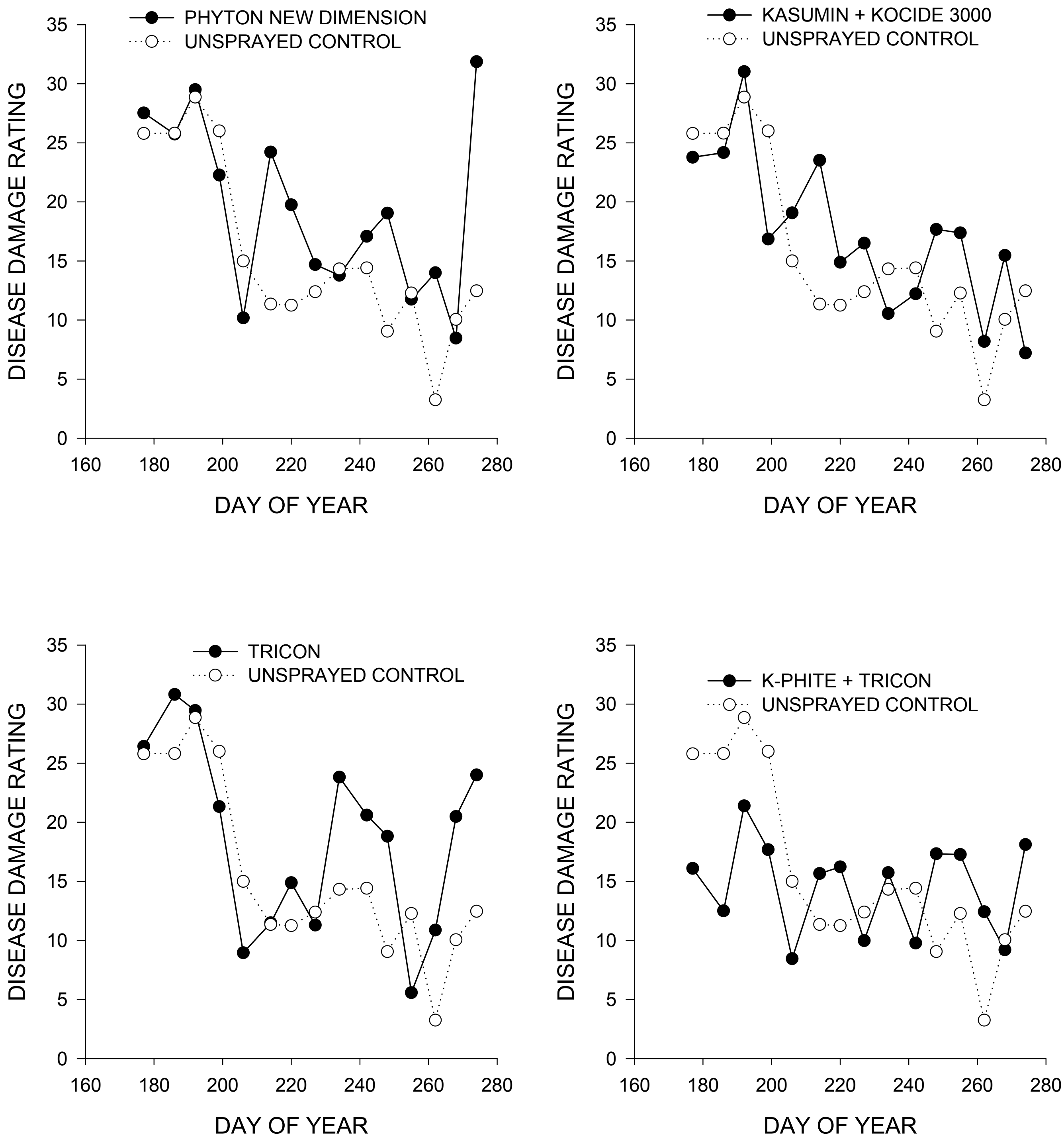

Figure 1A . Disease damage ratings of sampled leaves from Japanese Plum infected with *Xanthomonas campestris* pv. *pruni* during June through September, 2007 at Apopka, Florida.

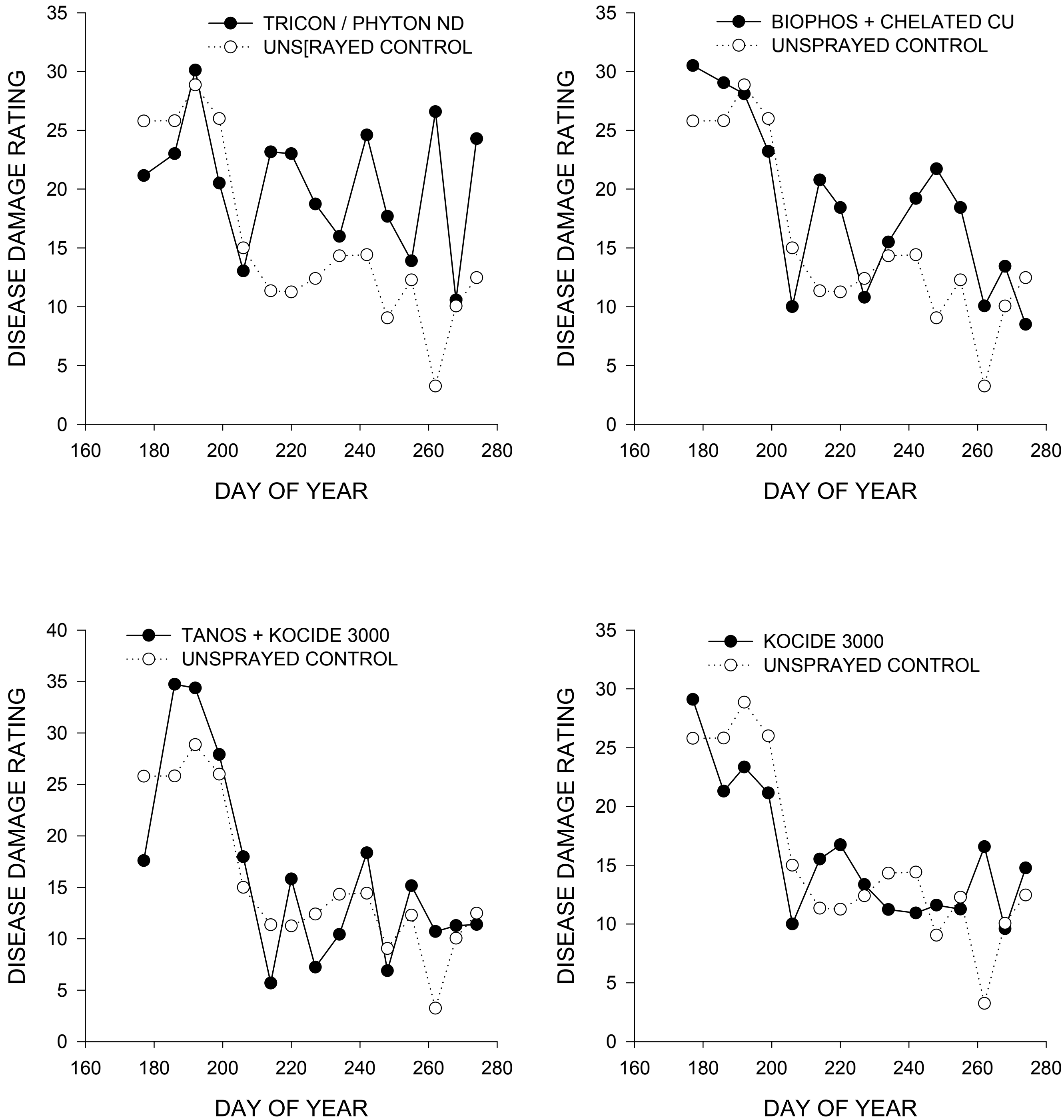

Figure 1A (continued). Disease damage ratings of sampled leaves from Japanese Plum infected with *Xanthomonas campestris* pv. *pruni* during June through September, 2007 at Apopka, Florida.

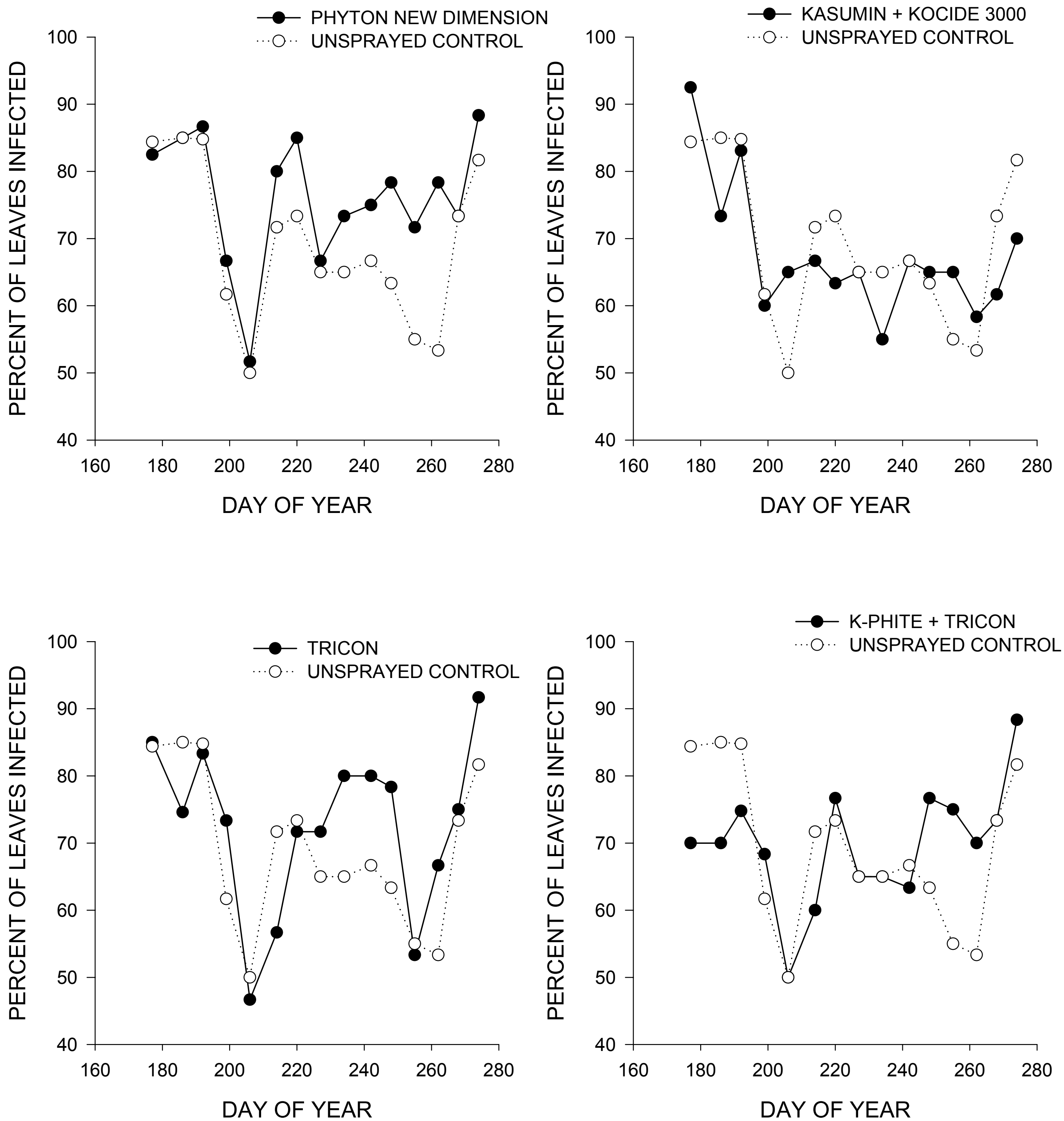

Figure 1B. Percent of sampled leaves from Japanese Plum infected by *Xanthomonas campestris* pv. *pruni* during June through September, 2007 at Apopka, Florida

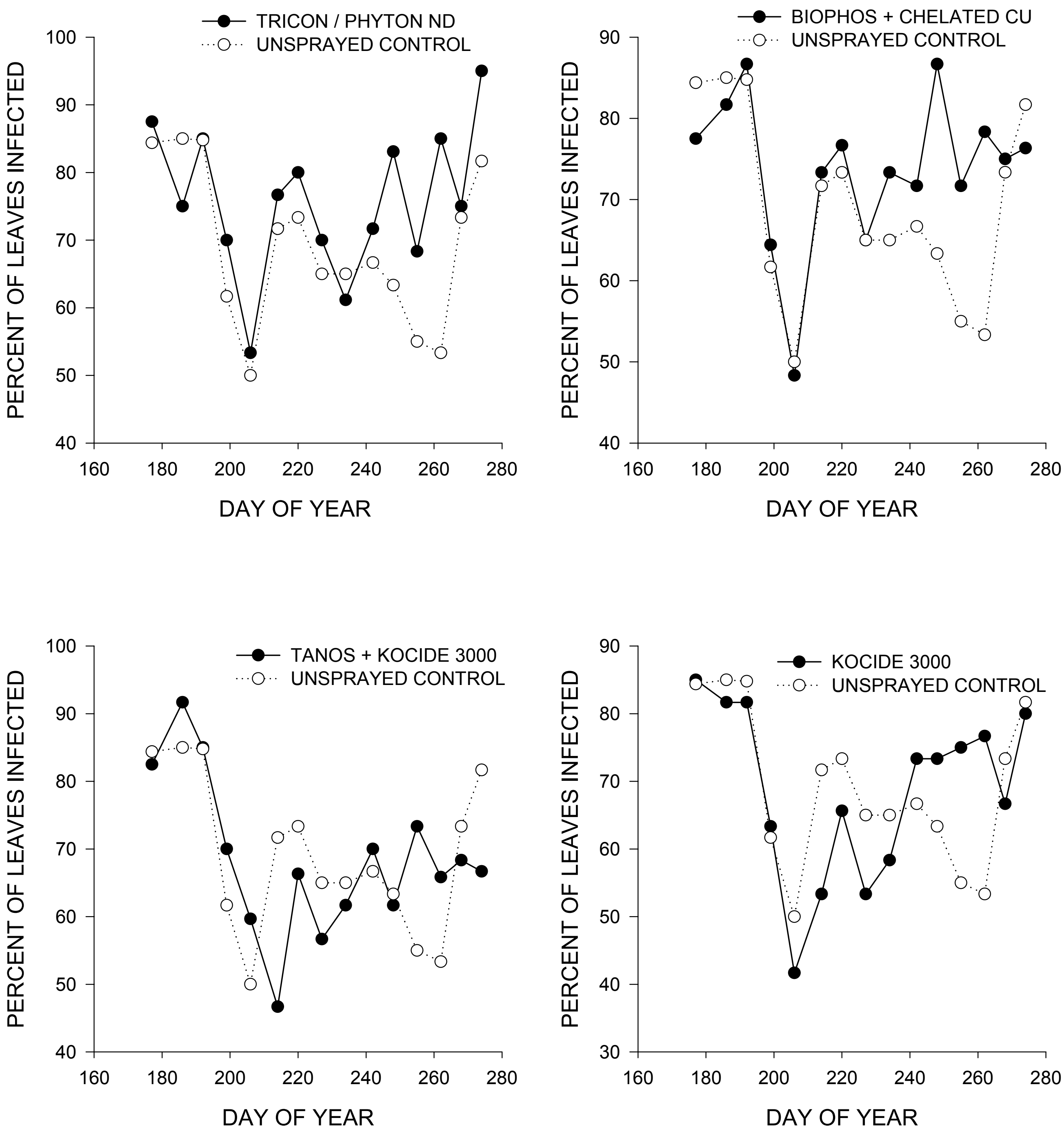

Figure 1B (continued). Percent of sampled leaves from Japanese Plum infected by *Xanthomonas campestris* pv. *pruni* during June through September, 2007 at Apopka, .Florida.

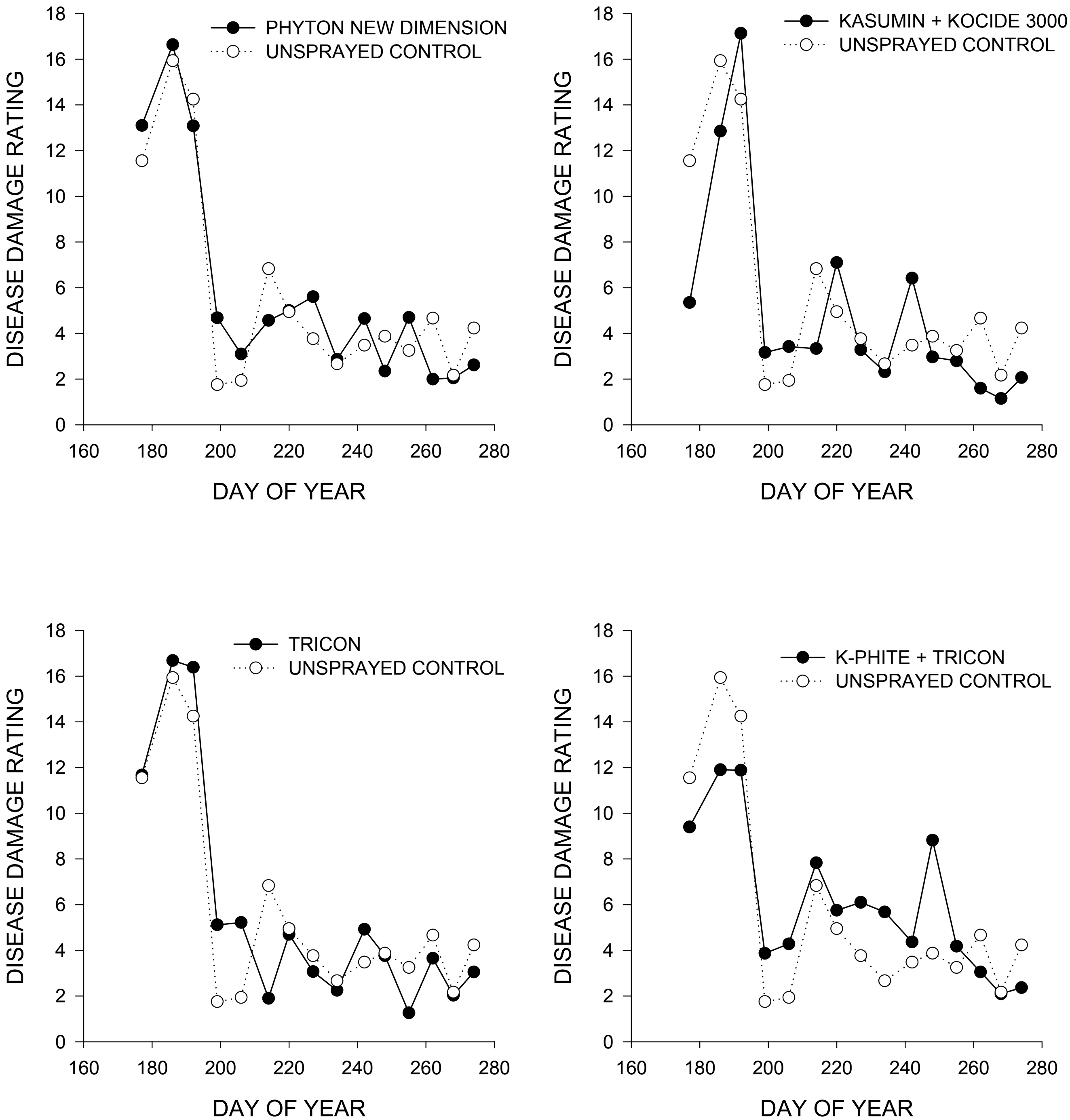

Figure 2A . Disease damage ratings of sampled leaves from Wax Myrtle infected with a *Xanthomonas* spp. (secies undetermined) during June through September, 2007 at Apopka, Florida.

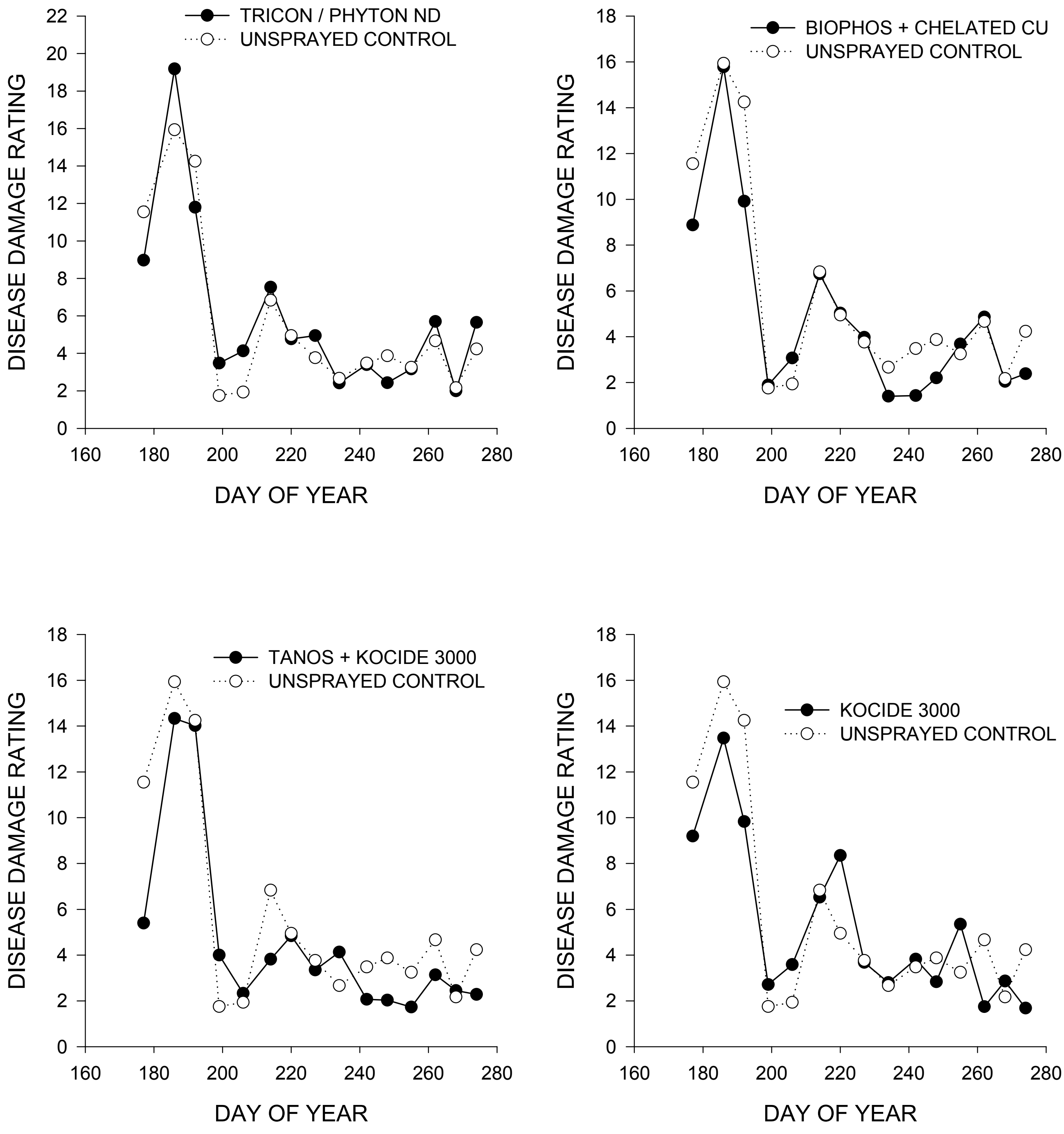

Figure 2A (continued). Disease damage ratings of sampled leaves from Wax Myrtle infected with a *Xanthomonas* spp. (species undetermined) during June through September, 2007 at Apopka, Florida.

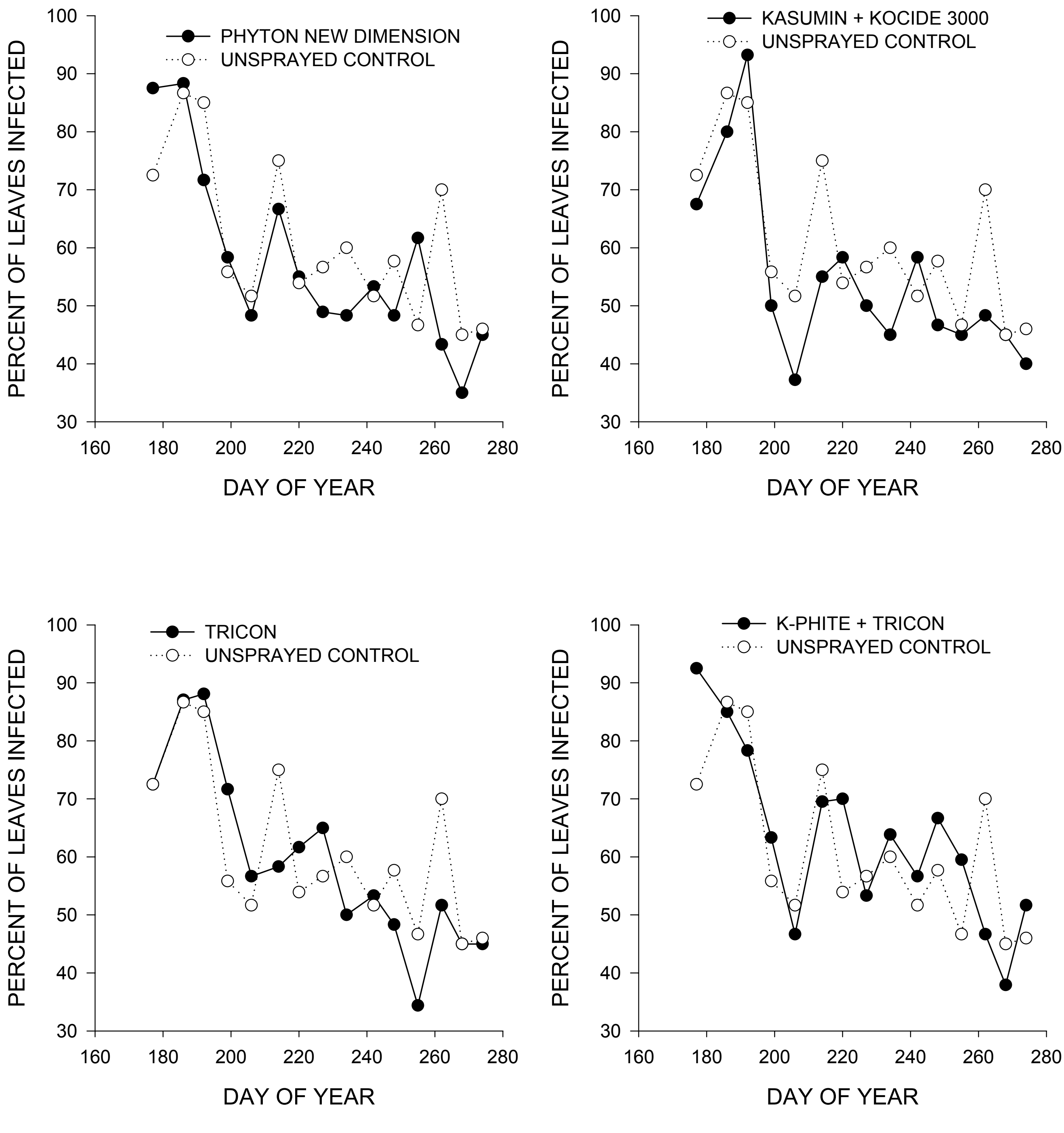

Figure 2B. Percent of sampled leaves from Wax Myrtle infected with a *Xanthomonas* spp. (species undetermined) during June through September, 2007 at Apopka, Florida.

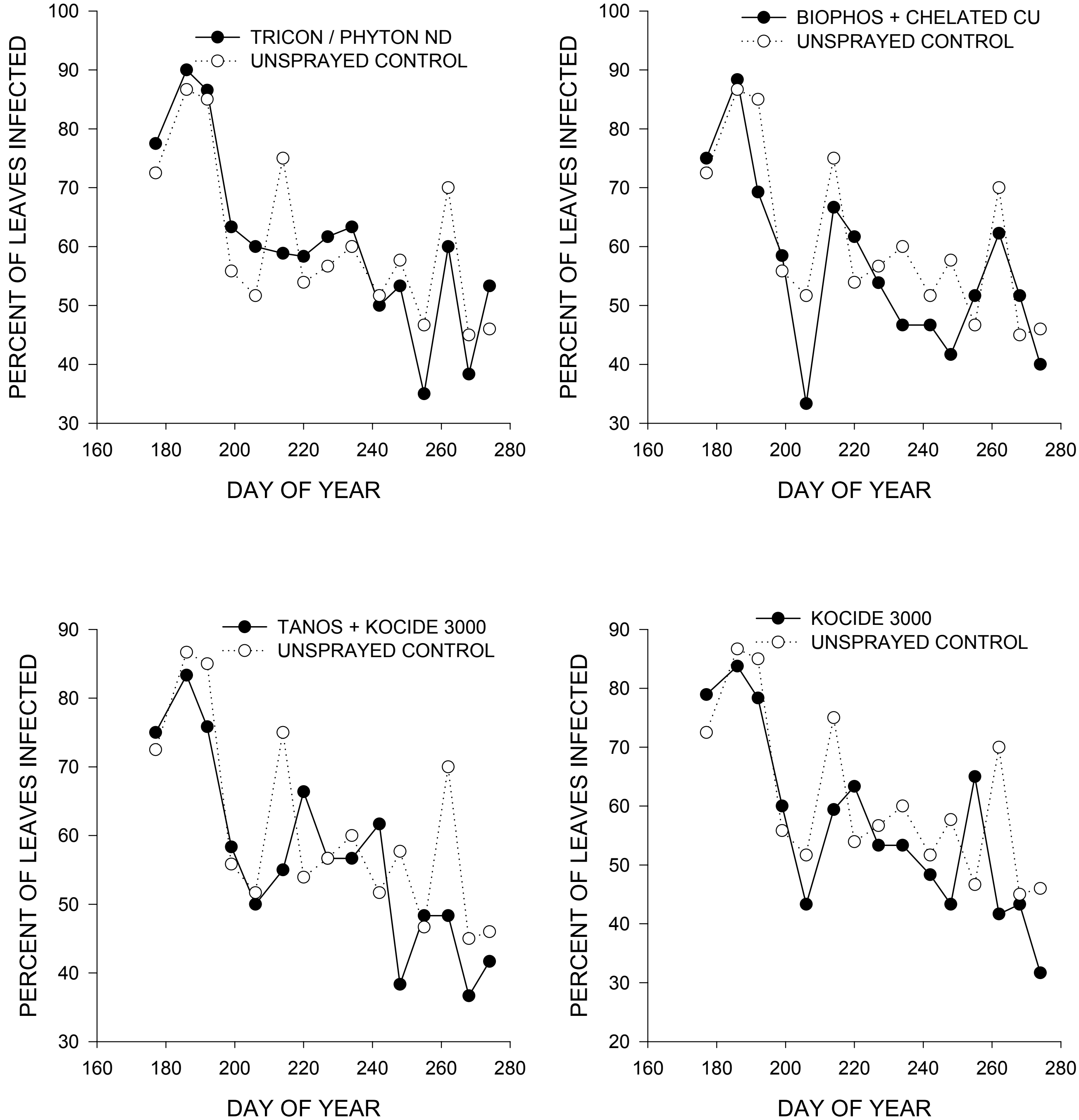

Figure 2B (continued). Percent of sampled leaves from Wax Myrtle infected with a *Xanthomonas* spp. (species undetermined) during June through September, 2007 at Apopka, Florida.

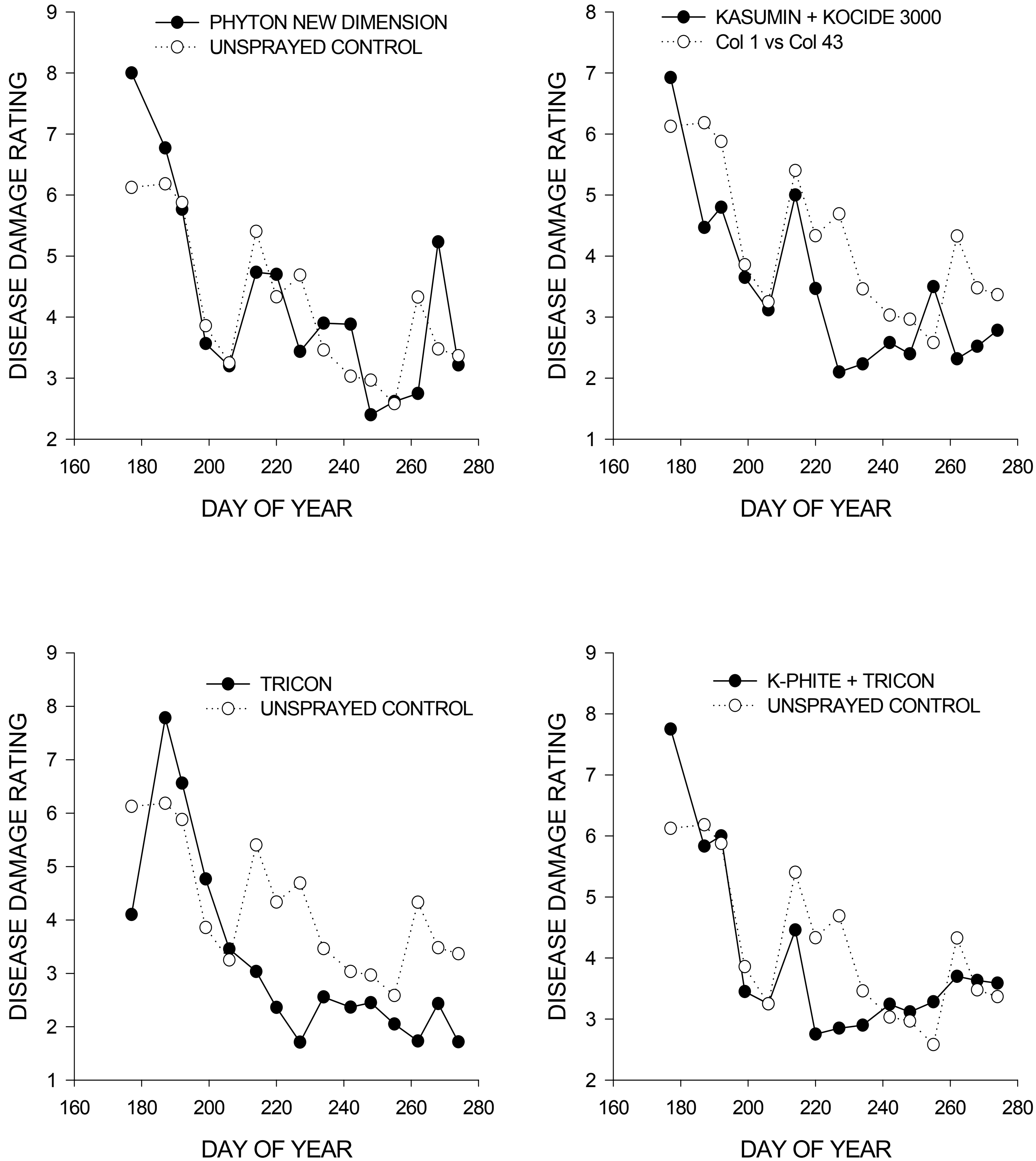

Figure 3A . Disease damage ratings of sampled leaves from Oak-Leaf Hydrangea infected with *Pseudomonas. marginalis* during June through September, 2007 at Apopka, Florida.

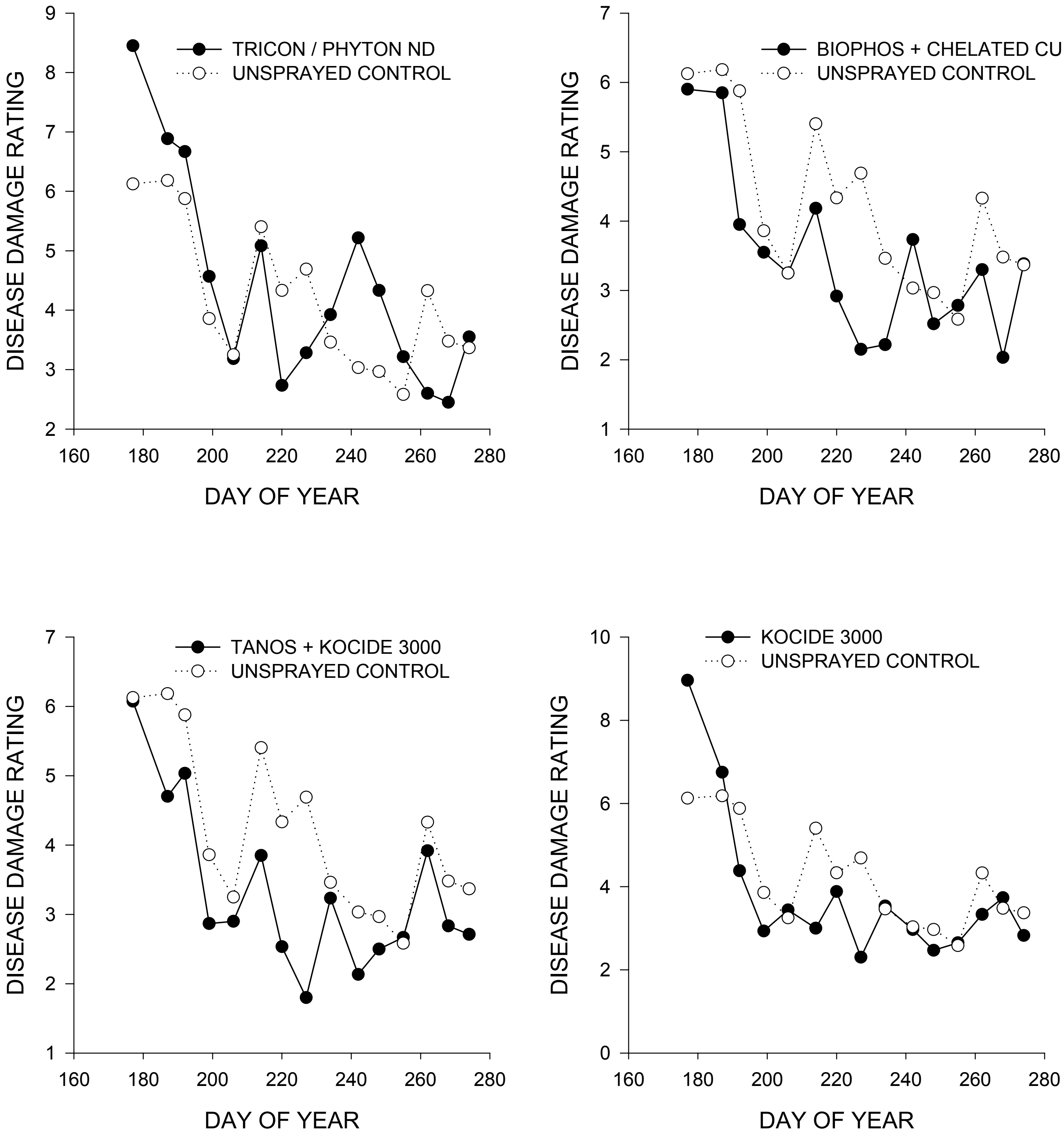

Figure 3A (continued). Disease damage ratings of sampled leaves from Oak-Leaf Hydrangea infected with *Pseudomonas. marginalis* during June through September, 2007 at Apopka, Florida.

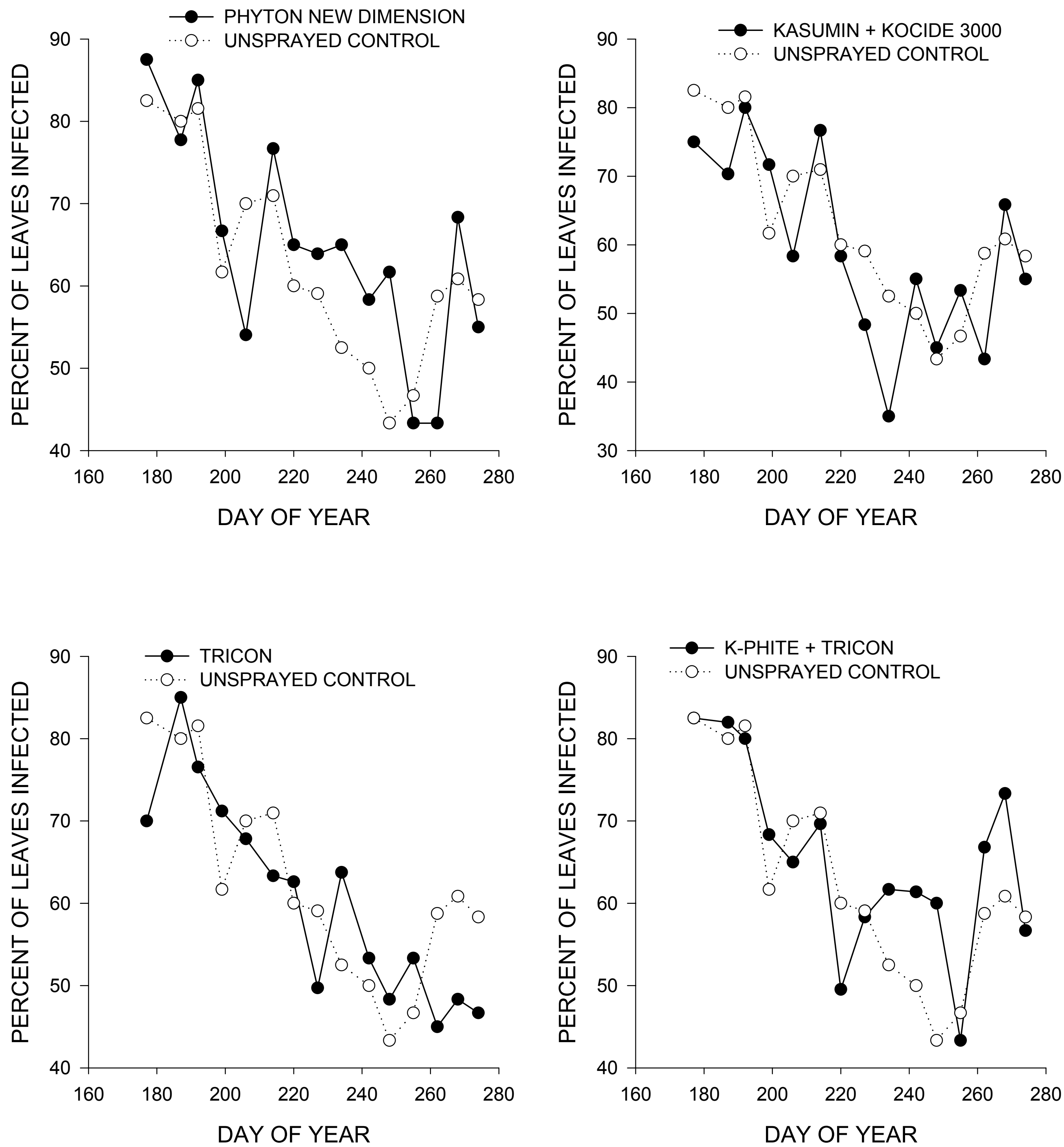

Figure 3 B. Percent of sampled leaves from Oak-Leaf Hydrangea infected with *Pseudomonas. marginalis* during June through September, 2007 at Apopka, Florida.

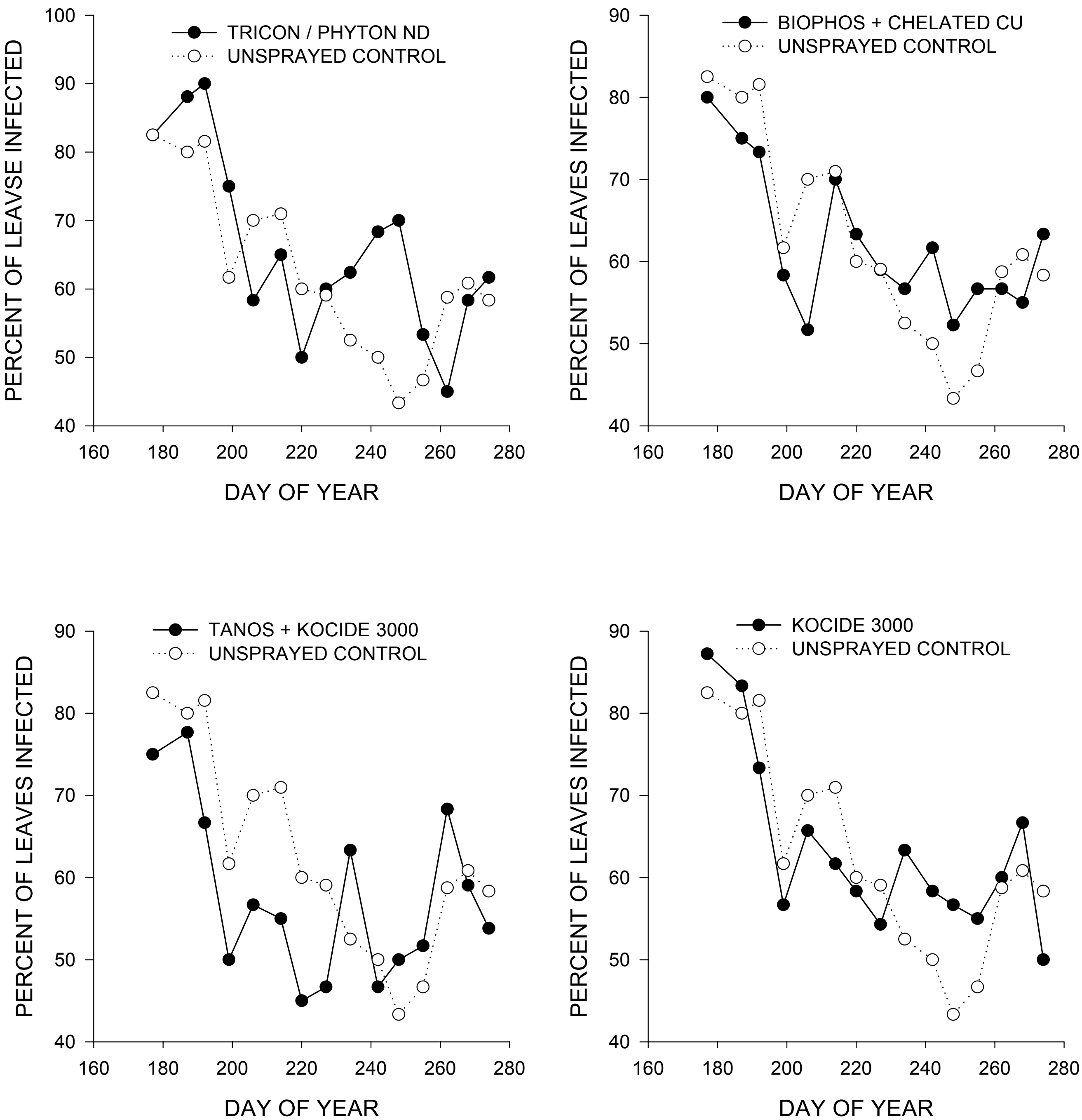

Figure 3 B (continued). Percent of sampled leaves from Oak-Leaf Hydrangea infected with *Pseudomonas marginalis* during June through September, 2007 at Apopka, Florida.

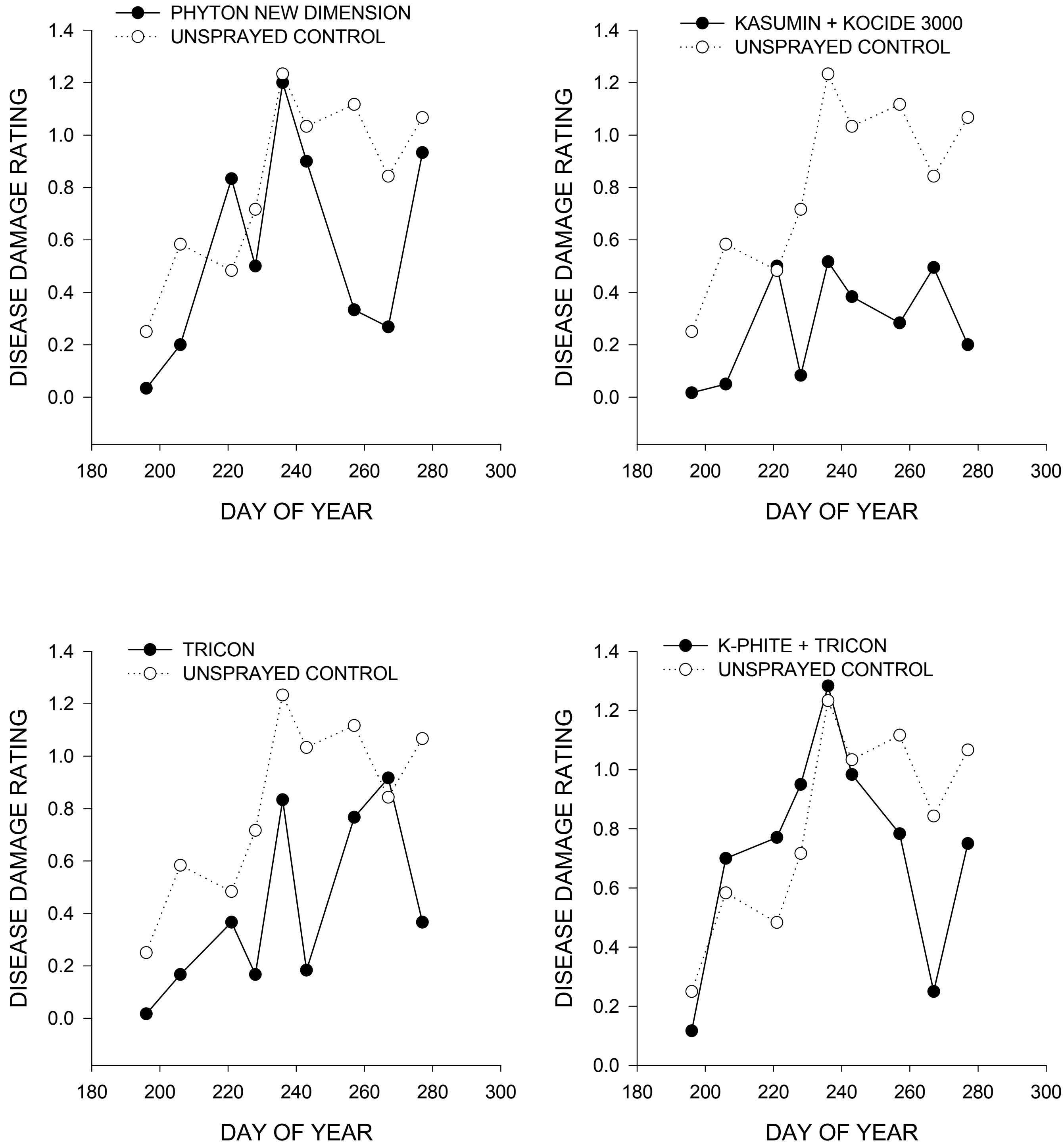

Figure 4A . Disease damage ratings of sampled leaves from Hibiscus infected with *Pseudomonas.chicorii* during June through September, 2007 at Apopka, Florida.

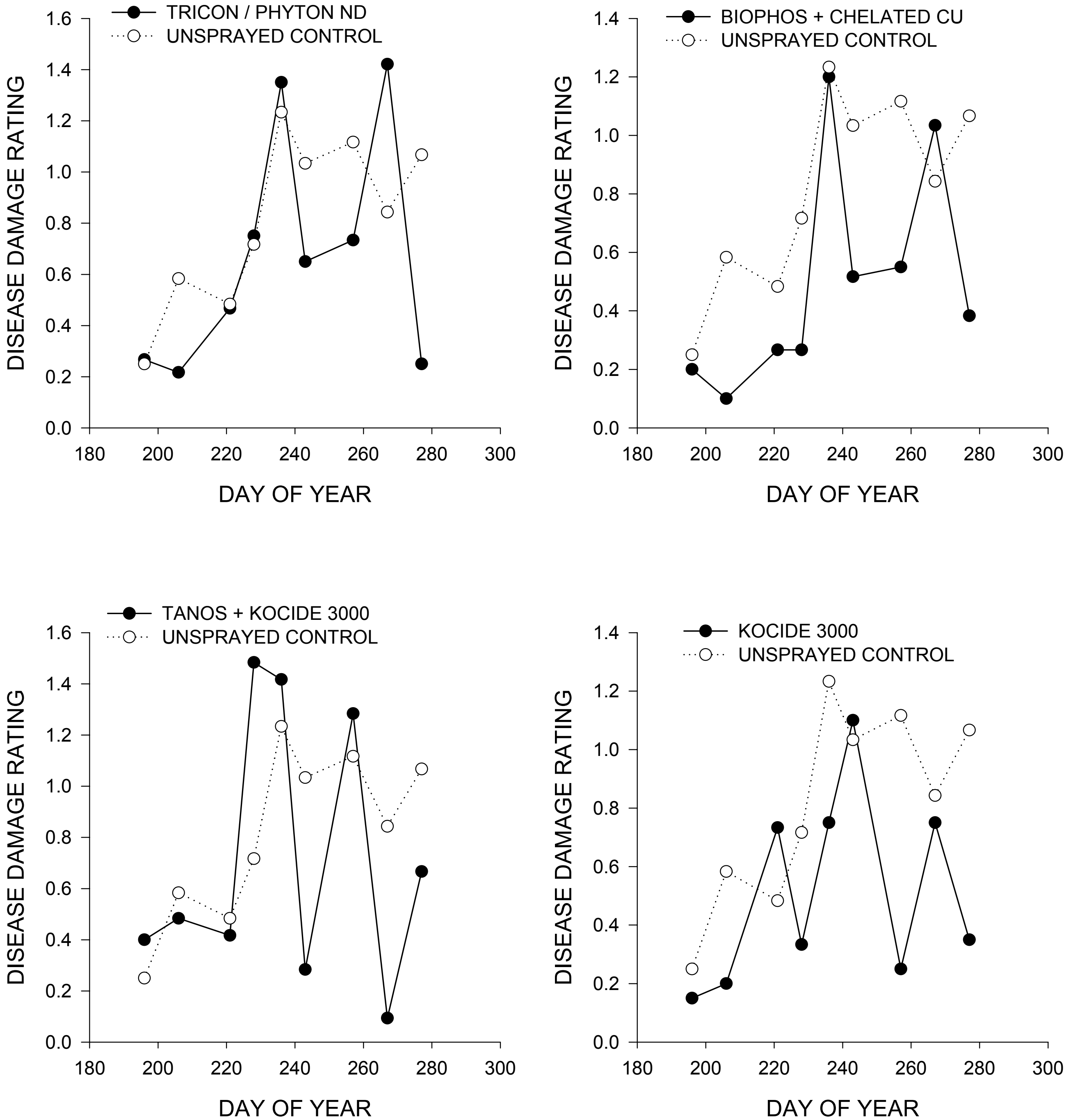

Figure 4A (continued). Disease damage ratings of sampled leaves from Hibiscus infected with *Pseudomonas.chicorii* during June through September, 2007 at Apopka, Florida.

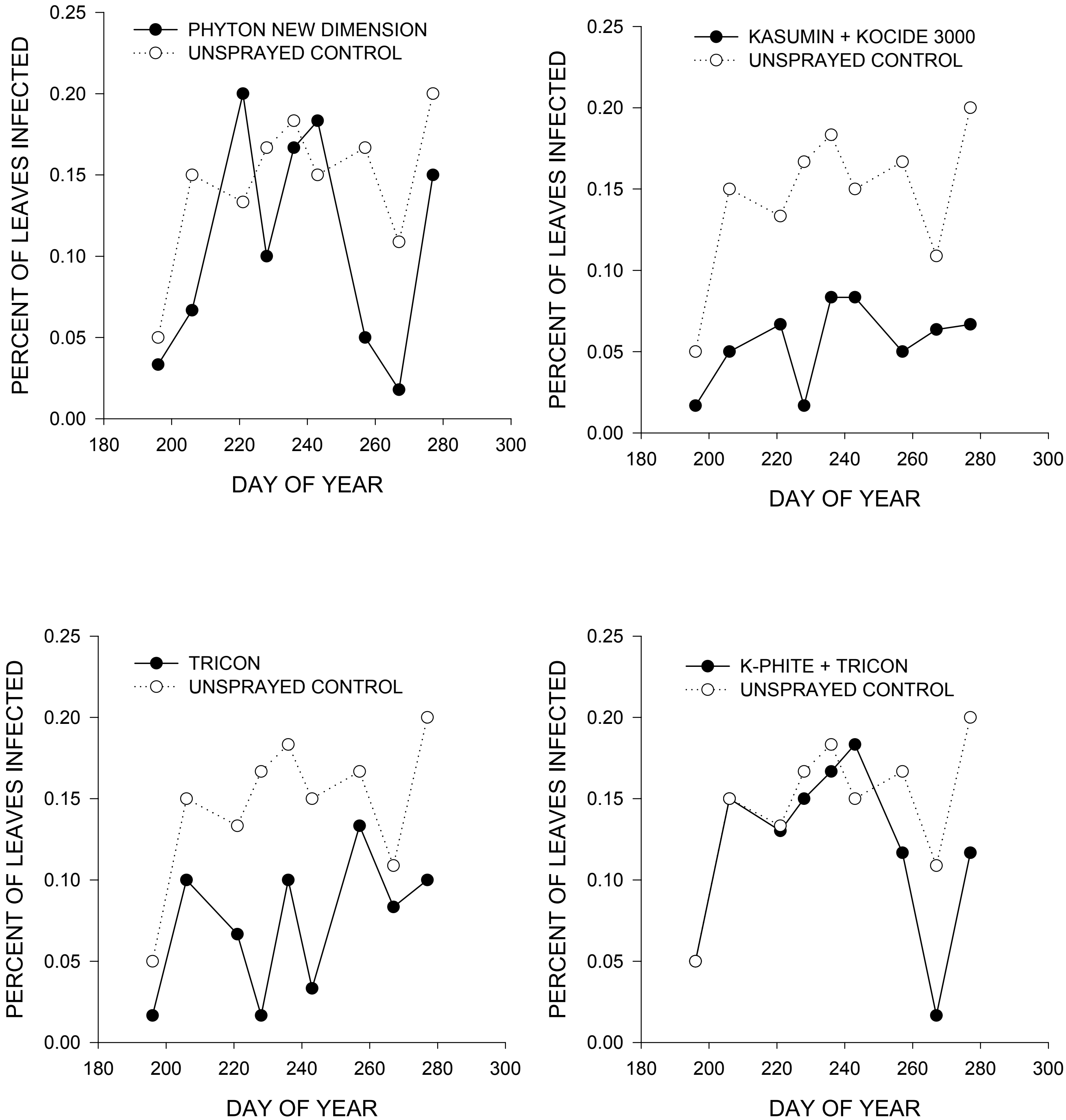

Figure 4B. Percent of sampled leaves from Hibiscus infected with *Pseudomonas.chicorii* during June through September, 2007 at Apopka, Florida.

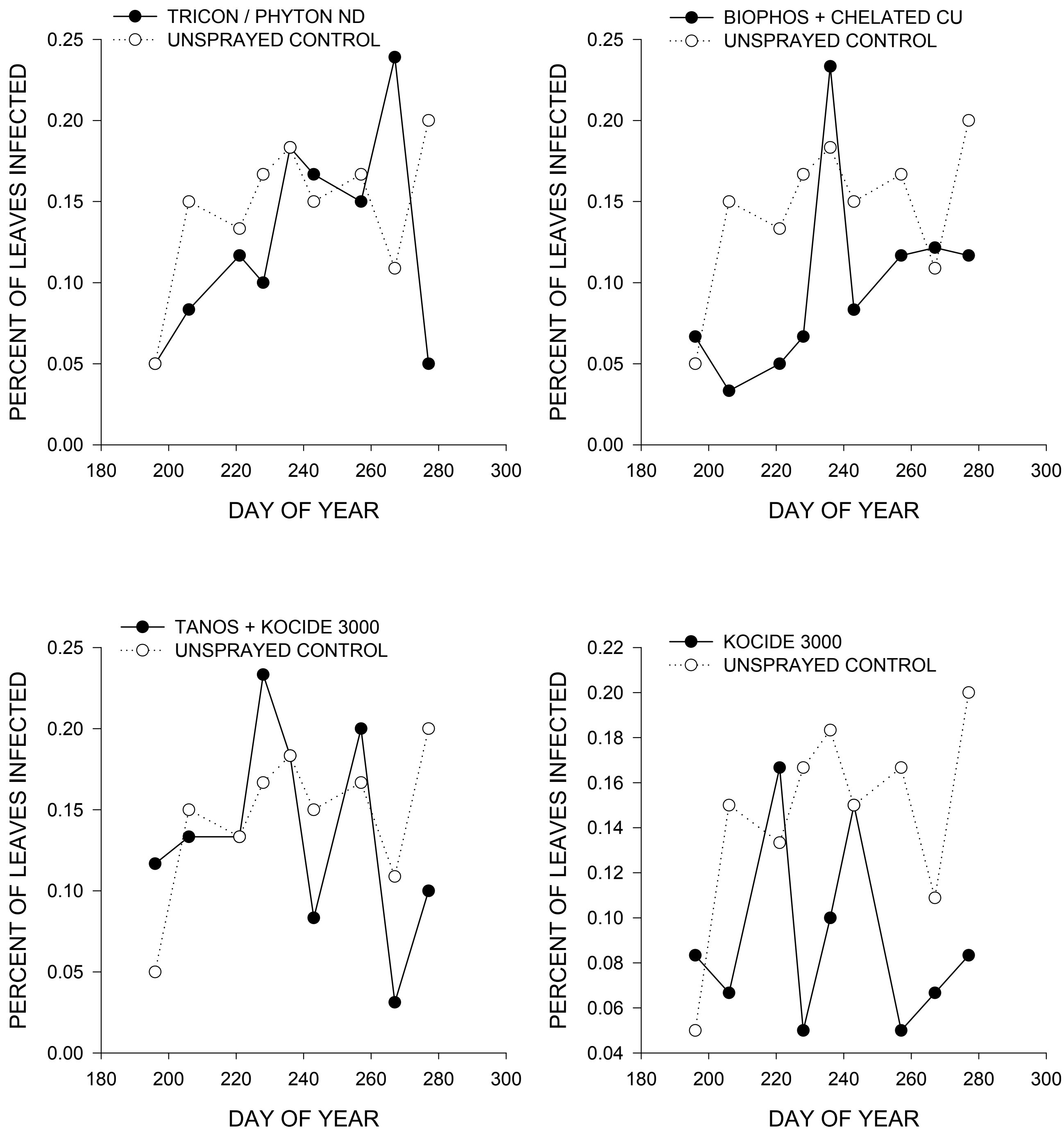

Figure 4B (continued). Percent of sampled leaves from Hibiscus infected with *Pseudomonas.chicorii* during June through September, 2007 at Apopka, Florida.