NEW PREVENTATIVE-SYSTEMIC COMBINATIONS COMPARED TO BRAVO® 500 AND RIDOMIL® MZ58 IN THE CONTROL OF PHYTOPHTHORA INFESTANS ON POTATO IN NORTHWEST WASHINGTON [1]

by
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ABSTRACT

In 1983 near Mt. Vernon, Wa., spray applications of two rates of San 371F + Bravo® 500 and San 518F (San 371F + Dithane® M-45) were compared to Ridomil® MZ58 and Bravo 500 alone for control of Phytophthora infestans in potato cv. "White Rose". All treatments significantly reduced foliage symptoms of late blight, and significantly increased % U.S. No. 1 tubers, and yield more than the untreated control. All treatments except Bravo 500, sprayed biweekly, reduced late blight tuber rot at harvest. Applying fungicides prior to appearance of late blight lesions reduced foliage symptoms of late blight and tuber rot and increased yields significantly more than applying fungicides after the appearance of late blight symptoms. San 518F, San 371F + Bravo 500 and Bravo 500 alone were similar in their effects on late blight control and potato production, but they were less effective than Ridomil MZ58. San 518F gave significantly better late blight control and yields than San 371F + Bravo 500 when the treatments were applied prior to late blight but not when applied after the symptoms of late blight occurred.

In 1984, 13 weekly foliage applications of Bravo 500 alone; eight weekly applications of Bravo 500 followed by three biweekly applications of preventative-systemic combinations of either DS-63049 (9% San 371F + 72% Bravo 500), San 518F or Ridomil MZ58; and seven biweekly applications of either DS 63049, San 518F or Ridomil MZ58 significantly reduced foliage blight and late blight tuber rot at harvest and significantly increased yield as compared to the untreated control. All three combination treatments gave significantly less control of P. infestans when applied once, after appearance of late blight as compared to combinations applied biweekly full season.

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Mention of a product used in these studies does not constitute a recommendation of the product by Washington State University over other products.

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INTRODUCTION

In Northwest Washington, late blight caused by Phytophthora infestans (Mont.) de Bary, occurs annually. Biweekly or monthly foliage sprays of metalaxyl, Ridomil® 2E, (N-(2-6 dimethylphenyl)-N-(methoxyacetyl)-alanine methyl ester) and Ridomil MZ58®, (metalaxyl + zinc ion and manganese ethylene bisdithiocarbamate) were equal to biweekly sprays of Bravo 500 (tetrachloroisophthalonitrile), and mancozeb, Dithane® M-45, (zinc ion and manganese ethylene bisdithiocarbamate) in control of P. infestans (Easton, G., unpublished). They also prevented late blight tuber rot (3). Ridomil has been reported to eradicate P. infestans (3). Recently San 371F 25 WP, oxadixyl, (2-methoxy-N-(2-oxo-1, 3-oxazolidin-3-yl)-acet-2', 6'=xylidide), and San 518F (8% San 371F and 56% Dithane M-45)from Sandoz, Inc., Crop Protection, 480 Camino del Rio South, San Diego, Ca. 92108 and DS-63049 (9% San 371F + 72% Bravo 500) from SDS Biotech Corporation, 7528 Auburn Road, P. O. Box 348, Painesvelle, Oh. 44077 became available to be evaluated for control of P. infestans (4,7).

This paper reports a two year study on control of P. infestans with foliage sprays of San 371F plus either Bravo 500 (two rates) or San 371F plus Dithane M-45 (San 518F) and a study of Bravo 500 followed by either DS-63049, San 518F or Ridomil MZ58 and each of these combinations alone compared to Bravo 500 alone for control of P. infestans. Dithane M-45 alone was not included since control with it is about equal to that with Bravo 500 (2). San 371F was not tested alone since Sandoz Inc. and SDS Biotech Corporation do not plan to market it alone, but in combination with other late blight-early blight protectant fungicides.

MATERIALS AND METHODS

The experiments were conducted near Mt. Vernon, Wa. on a Puget silt loam soil on the very susceptible potato cv. White Rose. In 1983, foliage sprays were applied before and after the first symptoms of late blight. Plots with no fungicide application served as control treatments. Plots were 9 ft wide (3 rows) by 20 ft long and all treatments were arranged in a randomized complete block design with six replications.

N, P, and K at 200, 100 and 500 lb/a, respectively, were broadcast, and the field plowed 12 inches deep. The field was planted May 18 both years.

In 1983 the plots were sprayed with four fungicide treatments on June 30, prior to late blight appearance and again with the four treatments on July 27 and August 24, after late blight was present. Prior to late blight, plots were sprayed once with San 518F 64 WP at 1.2 and 1.6 lb ai/a; San 371F 25 WP + Bravo 500 40.4E at 0.64 + 0.5 lb ai/a; or Ridomil MZ58 at 1.1 lb ai/a. Other plots were sprayed on July 27 after the first appearance of late blight, and again on September 7 with San 518F at 1.6 lb ai/a, San 371F + Bravo 500 at 0.79 + 1.0 lb ai/a and Ridomil MZ58 at 1.4 lb ai/a. Bravo 500 sprays, 1.1 lb ai/a, were applied prior to late blight on still other plots, on June 30 and then following late blight sprayed five times biweekly with the last spray on September 7.

Spray rates were increased after late blight occurred to provide more curative control. All fungicides were mixed with water and sprayed in 25 gal of solution/a at 24 psi with a hand-carried, gas-engine-powered sprayer with boom.

In 1984, 15 treatments were applied as follows: untreated; Bravo 500 sprayed at weekly intervals 13 times, starting at 0.59 lb ai/a on July 10 and 17, at 0.78 lb ai/a on July 23 and at 1.04 lb ai/a on July 31 and nine times thereafter, until October 2; Bravo 500 sprayed as above but discontinued on Aug. 28 and then followed by either DS-63049 at 1.37 lb ai/a or San 518F at 1.22 lb ai/a or Ridomil MZ58 at 0.74 lb ai/a sprayed at two-week intervals starting on Sept. 4 and twice thereafter until October 2; Bravo 500 as above, except the three combinations were sprayed once on September 4 after late blight had appeared in unsprayed plots; DS-63049, San 518F or Ridomil MZ58 sprayed seven times biweekly from July 10 until October 2; and DS-63049, San 518F, or Ridomil MZ58 sprayed once on September 4 after late blight appeared in unsprayed plots. The field was sprinkle irrigated at regular intervals to maintain potato growth and to increase relative humidity to favor late blight infection.

Plant defoliation and death due to late blight were estimated five times at 2-wk intervals starting July 27, 1983 and three times at 2-wk intervals starting September 11, 1984. Measurements were based on a scale of 0 = no foliar lesion to 10 = all leaves infected and plants completely defoliated.

June through October precipitation data were taken from records of a weather station 1 mile from the testing site. On September 30, 1983 and October 9, 1984, foliage was killed with a desiccant, dinoseb (2-sec-butyl- 4, 6-dinitrophenol) applied at 5.0 lb ai/a in water at 50 gal of solution/a. All foliage was dead at harvest on October 25, 1983 and October 30, 1984. Yields were taken from the center row of each plot. Tubers were washed and graded and the weight of tubers with late blight lesions were recorded. Blight-free tubers were held at 37 to 41 F until March 1983 to measure development of additional tuber rot.

Orthogonal and non-orthogonal data comparisons were used to test significance at $p=0.01$ level according to the F test (5).

RESULTS

In 1983, wet weather, favorable for late blight occurred during the experiment. Mean temperatures and rainfall were 61.7 and 3.58, 60.9 and 2.67, 62.9 and 1.10, 56.1 3.50 and 49.4 F and 1.69 inches for June, July, August, September, and October, respectively. Late blight lesions on foliage appeared July 27, and untreated plots were completely defoliated by late August.

In 1984, weather favorable for late blight didn't occur until August. Mean temperatures and rainfall were 58.4 and 2.11, 61.6 and 0.02, 62.2 and 1.73, 56.5 and 3.32, and 48.3 F and 3.16 inches for June, July, August, September, and October, respectively. Late blight was observed in the field on August 14 and a trace occurred in all non-treated plots by September 4.

In 1983, all fungicide treatments significantly reduced foliage late blight, increased % U.S. No. 1 tubers and increased yields more than the untreated control (Table 1). All treatments, except Bravo 500 alone, also reduced late blight tuber rot at harvest. Sprays initiated before July 27 when late blight appeared, significantly reduced foliage late blight and increased yields compared to sprays applied after appearance of late blight. San 518F and San 371F + Bravo 500 were comparable to Bravo 500 in disease control and tuber production, but they were not as good as Ridomil MZ58. San 518F gave significantly better late blight control and yields than did San 371F + Bravo 500 when applied before late blight appeared but not when they were applied after appearance of late blight. San 518F at 1.6 lb ai/a significantly reduced late blight and increased yields more than when applied at 1.2 lb ai/a.

Late blight tuber rot did not develop in storage by March 14, 1984 regardless of treatment.

In 1984, all chemical treatments significantly reduced late blight foliage symptoms and tuber rot and increased yields significantly more than the untreated control (Table 2). Plots treated with thirteen weekly foliage applications of Bravo 500 had significantly less foliage late blight on October 9 and less late blight tuber rot than other chemical treatments, but it did not affect yield. Bravo 500 followed by the three combination treatments of DS-63049, San 518 and Ridomil MZ58 applied full season had significantly less foliage late blight on October 9, less late blight tuber rot, and significantly higher yields than Bravo 500 followed by the combination treatments applied once after late blight first appeared in untreated plots. All combination treatments of DS-63049, San 518 and Ridomil MZ58 applied full season biweekly had significantly less foliage late blight all season, less late blight tuber rot, and significantly higher yields than combination treatments applied once after appearance of late blight. Bravo 500 followed by the three combination treatments applied three times significantly reduced foliage late blight and reduced late blight tuber rot, but did not significantly increase yield more than the three combination treatments applied seven times all season. Bravo 500 followed by DS-63049 and Bravo 500 followed by San 518F applied three times were equal to Bravo 500 followed by Ridomil MZ58 applied three times in late blight control and tuber production. Bravo 500 followed by DS-63049 had significantly more late blight tuber rot and significantly less yield than Bravo 500 followed by San 518F applied three times. Bravo 500 followed by DS-63049 and Bravo 500 followed by San 518F (applied once) after the appearance of late blight had significantly more late blight tuber rot and significantly less yield than Bravo 500 followed by Ridomil MZ58 (applied once). Bravo 500 followed by DS-63049 (applied once) was equal to Bravo 500 followed by 518F (applied once) for late blight control but had significantly more yield. DS-63049 and San 518F applied full season were equal to Ridomil MZ58 applied full season for late blight control, but had significantly less yield. Late blight control was similar for DS-63049 and San 518F applied full season, but DS-63049 treated plots significantly out yielded San 518F plots. Yields were equal for DS-63049 and San 518F compared to Ridomil MZ58 when all were applied once but they had significantly more foliage late blight and tuber rot than plots treated with Ridomil MZ58.

DS-63049 applied once had significantly more late blight tuber rot and significantly less yield than San 518F applied once. Treatments of Bravo 500 followed by each of the three numbered chemical combinations applied full season were about equal for control of P. infestans and potato production to the three combination chemical treatments each applied full season. Bravo 500 followed by each of the three numbered combination treatments applied once had significantly less foliage late blight and less late blight tuber rot and significantly more yield than the three combination treatments (individually applied once after the appearance of late blight. In 1984, none of the treatments significantly affected % U.S. No. 1 tubers.

DISCUSSION

In 1983, San 518F composed of San 371F + Dithane M-45, was more effective than the two rates of San 371F + Bravo 500 in reducing late blight but less effective than Ridomil MZ58. In general, this agrees with results in Maine under moderate disease pressure, where San 518F sprays resulted in less late blight defoliation than San 371F, however in Maine San 518F was equal in control to Ridomil MZ58 + Dithane M-45 (6).

In 1983, plots sprayed with six foliage sprays of Bravo 500 applied biweekly had more late blight foliage and tuber rot at harvest than those treated with San 518F, San 371F + Bravo 500 or Ridomil MZ58. Under the severe disease pressure of that year, Bravo 500 would probably have performed better if sprayed weekly and until harvest (1). In 1984, under moderately-severe disease pressure, 13 weekly sprays of Bravo 500 were equal in control of P. infestans to any other treatment.

In 1983, under severe late blight conditions none of the fungicides eradicated P. infestans. Likewise, in 1984, combination treatments applied once after the appearance of late blight, did not stop late blight. This agrees with results of a previous study which showed that systemic fungicides need to be applied prior to the disease to be the most effective (unpublished, Easton, G.D.). These observations do not agree with results in New York where Ridomil retarded an impending epidemic within two days (3).

In 1984, Ridomil MZ58 applied once only at 0.74 lb ai/a appeared to be a better combination fungicide for the control of late blight tuber rot than DS-63049 at 1.37 lb ai/a and San 518F at 1.22 lb ai/a applied once only. DS-63049 gave less control of P. infestans than San 518F and will apparently have to be applied more often than the other two combination treatments. Applying any of the three combination treatments before appearance of late blight increases their effectiveness for control of P. infestans and reduces the number of applications needed.

We wish to thank the Washington State Potato Commission, SDS Biotech Corporation, and Sandoz, Inc., for products and grants to support this study.

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Table 1. Control of Phytophthora infestans and tuber production in cv. White Rose as affected by systemic and non-systemic fungicide combinations applied to foliage either prior to or after initial late blight symptoms.

Fungicides, lb ai/a	Late blight foliage disease index[t] 7-27	8-10	8-24	9-7	9-22	% late blight tuber rot (10-25)	% U.S. No. 1 tubers (weight)	Yield (cwt/a)
Orthogonal Data Comparisons								
Sprayed Prior to Late Blight[u]								
San 518F 64WP (1.2), San 518F (1.6) and San 371F 25WP + Bravo 500 (0.64 + 0.5) versus (vs) Ridomil MZ58 (1.1)	1.7 vs 1.3	2.9*[y] vs 1.2	3.4**[z] vs 1.2	6.1** vs 2.8	8.6** vs 7.0	6.8** vs 2.5	77 vs 77	412 vs 634**
San 518F (1.2) vs San 518F (1.6) and San 371F + Bravo 500 (0.64 + 0.5)	2.2 vs 1.6	3.0 vs 2.8	3.8 vs 3.2	6.3 vs 6.0	8.8 vs 8.5	7.7 vs 6.3	76 vs 77	384 vs 425
San 518F (1.6) vs San 371F + Bravo 500 (0.64 + 0.5)	1.5 vs 1.7	2.5 vs 3.2	3.0 vs 3.3	5.5 vs 6.5	8.0 vs 9.0**	4.3 vs 8.3	77 vs 74	475* vs 375
San 518F (1.2), San 518F (1.6) and San 371F + Bravo 500 (0.64 + 0.5) vs Bravo 500 (1.0)[v]	1.7 vs 0.8	2.9 vs 1.8	3.4 vs 2.5	6.1 vs 6.0	8.6** vs 7.0	6.8 vs 14.3**	77 vs 79	412 vs 430
San 371F + Bravo 500 (0.64 + 0.5) vs Bravo 500 (1.0)	1.7 vs 0.8	3.2 vs 1.8	3.3 vs 2.5	6.5 vs 6.0	9.0 vs 9.7**	8.3 vs 14.3**	74 vs 79	376 vs 430
Sprayed After Late Blight[w]								
San 518F (1.6) and San 371F + Bravo 500 (0.79 + 1.0) vs Ridomil MZ58 (1.4)	3.9 vs 4.0	4.0 vs 2.7	4.7* vs 2.8	8.5** vs 6.0	10.0** vs 8.7	14.5** vs 3.8	74 vs 78	282 vs 479**
San 518F (1.6) vs San 371F + Bravo 500 (0.79 + 1.0)	3.7 vs 4.2	3.8 vs 4.2	4.5 vs 4.8	8.2 vs 8.8	10.0 vs 10.0	11.5 vs 17.5*	75 vs 73	284 vs 282
All Fungicides Sprayed Prior to vs All Fungicides After Late Blight	1.5 vs 3.9**	2.3 vs 3.6**	2.8 vs 4.1**	5.4 vs 7.7**	8.5 vs 9.6**	7.4 vs 10.9**	77 vs 75	460** vs 348

Table continued . . .

Table 1, continued

Fungicides, lb ai/a	Late blight foliage disease index[t] 7-27	8-10	8-24	9-7	9-22	% late blight tuber rot (10-25)	% U.S. No. 1 tubers (weight)	Yield (cwt/a)
Non-Orthogonal Data Comparisons[x u]								
Sprayed Prior to Late Blight								
San 518F (1.2), San 518F (1.6) and San 371F + Bravo 500 (0.64 + 0.5) vs untreated	1.7 vs 3.8**	2.9 vs 6.0**	3.4 vs 9.2**	6.1 vs 10.0**	8.6 vs 10.0**	6.8 vs 16.5**	75** vs 56	412** vs 160
San 518F (1.2) vs San 518F (1.6)	2.0 vs 1.5	3.0 vs 2.5	3.8 vs 3.0	6.3 vs 5.5	8.8** vs 8.0	7.7 vs 4.3	76 vs 80	384 vs 475**
Ridomil MZ58 (1.1) vs untreated	1.3 vs 3.8**	1.2 vs 6.0**	3.3 vs 9.2**	2.8 vs 10.0**	7.0 vs 10.0**	2.5 vs 16.5**	77** vs 56	634** vs 160
Bravo 500 (1.0) vs untreated	0.8 vs 3.8**	1.8 vs 6.0**	2.5 vs 9.2**	6.0 vs 10.0**	9.7 vs 10.0	14.3 vs 16.5	79** vs 56	430** vs 160
Ridomil MZ58 (1.1) vs Bravo 500 (1.0)	1.3 vs 0.8	1.2 vs 1.8	1.2 vs 2.5	2.8 vs 6.0**	7.0 vs 9.7**	2.5 vs 14.3**	77 vs 79	634** vs 430
Sprayed After Late Blight[w]								
San 518F (1.6) and San 371F + Bravo 500 (0.79 + 1.0) vs untreated	3.9 vs 3.8	3.4 vs 6.0**	4.7 vs 9.2**	8.5 vs 10.0**	10.0 vs 10.0	14.5 vs 16.5	74** vs 56	282** vs 160
Ridomil MZ58 (1.4) vs untreated	4.0 vs 3.8	2.7 vs 6.0**	2.8 vs 9.2**	6.0 vs 10.0**	8.7 vs 10.0**	3.8 vs 16.5**	78** vs 56	479** vs 160

[t] Index 0-10, 0 = no foliage with lesions and 10 = all leaves infected and plants defoliated.

[u] Sprayed three times prior to late blight symptoms in 25 gal of water/a.

Table continued . . .

Table 1, continued

[v]Bravo 500 sprayed six times at 2-wk intervals in 25 gal of water/a.

[w]Sprayed two times after first appearance of late blight symptoms in 25 gal of water/a.

[x]Non-orthogonal analysis made of these biological comparisons seemed appropriate although statistically the comparisons do not fit the rules.

[y] * = significantly different at $p=0.05$ according to F test.

[z] ** = significantly different at $p=0.01$ according to F test.

Table 2. Control of Phytophthora infestans and tuber production of potato cv. White Rose as affected by Bravo 500 and Bravo 500 plus systemic fungicide combinations applied once only and full season.

Orthogonal data comparison	Late blight foliage disease index[r] 11 Sept	25 Sept	9 Oct	% Late blight tuber rot 30 Oct	% U.S. No.1 tubers	Yield (cwt/a)
Untreated versus (vs) all chemical treatments	2.5**	8.0**	9.83**	17.0**	89	549
	vs	vs	vs	vs	vs	vs
	0.24	1.43	2.42	3.0	87	635**
Bravo 500 (BR)[s] vs all chemical treatments	0.08	1.08	1.42	1.2	87	640
	vs	vs	vs	vs	vs	vs
	0.24	1.46	2.5*	3.1**	87	634
BR[t] + all chemical combination treatments (CCT) applied full season[u] vs BR[t] + all CCT applied once only after late blight (LB)[v]	0.02	0.72	0.67	1.2	87	659**
	vs	vs	vs	vs	vs	vs
	0.0	0.5	1.78**	2.7**	87	638
All CCT applied full season[w] vs CCT applied once, only after LB[x]	0.03	0.83	1.5	1.4	85	660**
	vs	vs	vs	vs	vs	vs
	0.94**	3.78**	6.06**	7.2**	87	580
BR[t] + all CCT applied full season[u] vs all CCT applied full season[w]	0.01	0.61	1.22	2.0	87	648
	vs	vs	vs	vs	vs	vs
	0.49*	2.3**	3.78**	4.3**	86	620
BR[t] + DS-63049 81 WP (DS)[u] and BR[t] + San 518F 64 WP[u] (518) vs BR[t] + Ridomil MZ58 (MZ58)[u] applied full season	0.04	0.88	0.66	1.3	88	659
	vs	vs	vs	vs	vs	vs
	0.0	0.42	0.67	1.2	86	659
BR[t] + DS[w] vs BR[t] + 518[u] applied full season	0.08	1.0	0.5	2.2**	88	641
	vs	vs	vs	vs	vs	vs
	0.0	0.75	0.83	0.4	88	676**
BR[t] + DS[v] and BR + 518[v] vs BR + MZ58[v]--CCT applied once, only after LB	0.0	0.58	2.0	3.4**	87	625
	vs	vs	vs	vs	vs	vs
	0.0	0.33	1.33	1.3	87	664**

Table continued . . .

Table 2, continued

Orthogonal data comparison	Late blight foliage disease index[r] 11 Sept	25 Sept	9 Oct	% Late blight tuber rot 30 Oct	% U.S. No.1 tubers	Yield (cwt/a)
BR + DS[v] vs BR + 518[v]--CCT applied once, only after LB	0.0 vs 0.0	0.58 vs 0.58	2.25 vs 1.75	3.9 vs 2.9	87 vs 86	631** vs 618
DS[w] and 518[w] vs MZ58[w]--CCT applied full season	0.0 vs 0.4	0.96 vs 0.58	1.71 vs 1.08	1.6 vs 1.1	85 vs 87	657 vs 666*
DS[w] vs 518[w]--CCT applied full season	0.0 vs 0.8	1.0 vs 0.92	1.92 vs 1.5	1.2 vs 2.0	83 vs 88	672** vs 641
DS[x] and 518[x] vs MZ58[x]--CCT applied once only after LB	1.13 vs 0.58	4.08 vs 3.17	6.58** vs 5.0	9.6** vs 2.4	88 vs 86	579 vs 583
DS[x] vs 518[x]--CCT applied once only after LB	1.0 vs 1.25	3.67 vs 4.5	6.33 vs 6.83	10.3* vs 8.8	89 vs 86	568 vs 590**
Non-Orthogonal Data Comparisons[z]						
BR[t] + all CCT applied full season[u] vs all CCT applied full season[w]	0.3 vs 0.3	0.72 vs 0.83	0.66 vs 1.5*	1.2 vs 1.4	87 vs 85	659 vs 660
BR + all CCT applied once, only after LB[v] vs all CCT applied once, only after LB[x]	0.0 vs 0.94**	0.5 vs 3.78**	1.78 vs 6.06**	2.7 vs 7.2**	87 vs 87	638** vs 580

[r]Index 0-10, 0=no foliar lesions and 10=all leaves infected and plants completely defoliated.

Table continued . . .

Table 2, continued

[s]BR sprayed at weekly intervals starting at 0.59 lb ai/a on 10 and 17 July, at 0.78 lb ai/a on 23 July, and on 31 July at 1.04 lb ai/a and 9 times, thereafter until 2 Oct. The chemical was sprayed on foliage at 25 gal of solution/a at 24 psi.

[t]BR was sprayed as in [s], but discontinued after 28 Aug.

[u]Chemical combination treatment (CCT) DS-63049 was sprayed at 1.37 lb ai/a, San 518F was sprayed at 1.22 lb ai/a and Ridomil MZ58 was sprayed at 0.74 lb ai/a after discontinuance of BR at two week intervals starting on Sept 4 and twice, thereafter til Oct 2. These CCT were sprayed on foliage at 25 gal solution/a at 24 psi.

[v]BR sprayed as [t] plus CCT were sprayed as [u], but once only on 4 Sept after late blight appeared in unsprayed plots.

[w]CCT were sprayed every two weeks as in [u] but full season nine times starting on 10 July and thereafter til 2 Oct.

[x]CCT were sprayed as [u], but were sprayed once only on 4 Sept after late blight appeared in unsprayed plots.

[y]*=significant at $p=0.05$ according to F test, **=significant at $p=0.01$ according to F test.

[z]Non-orthogonal comparison made of these biological comparisons seemed appropriate although statistically the comparisons do not fit the rules.