SPINACH (*Spinacia oleracea* 'Viroflay')
Downy mildew; *Peronospora farinosa* f. sp. *spinaciae* (= *P. effusa*)

J. C. Correll[1], M.E. Matheron[2], S.T. Koike[3], M. Porchas[2], J. Pavel[1], and C. Feng[1]. [1]University of Arkansas, Fayetteville, AR 72701; [2]University of Arizona, Yuma Agricultural Center, Yuma, AZ 85364; [3]University of California, UCCE, Salinas, CA 93905.

Evaluation of biofungicides and conventional fungicides for management of downy mildew on spinach, 2015.

Downy mildew is the most economically important disease of spinach. Organic spinach production in California and Arizona comprises approximately 40% of total spinach production in the USA. Thus, there is a major need for registration of effective biofungicides for management of downy mildew in organic spinach fields. This study was conducted at the University of Arizona, Yuma Valley Agricultural Center. The soil was a silty clay loam (7-56-37 sand-silt-clay, pH 7.2, O.M. 0.7%). Cultivar Viroflay, known to be susceptible to all known races of the spinach downy mildew pathogen, was seeded, then sprinkler-irrigated to germinate the seed on 17 Jan on beds with 84 in. between bed centers, with each bed containing 32 rows of plants, at a seeding rate of 3.5 million seed per acre. All irrigation water was supplied by sprinkler irrigation or rainfall. Treatments were replicated three times in a randomized complete block design. Each replicate plot consisted of a 10 ft length of bed. Adjacent treatment beds were separated by single, non-treated beds. Treatments were applied with a CO_2 backpack sprayer that delivered 50/gal per acre at 40 psi through flat-fan nozzles. Foliar applications of treatments were made on 6, 16, and 23 Feb. Downy mildew was first observed in plots on 10 Feb, between the first and second fungicide applications. Maximum and minimum air temperature ranges (°F) were as follows: 54-81 and 27-56 during Jan, 70-88 and 40-58 during Feb, and 62-84 and 42-58 during 1 to 10 Mar, respectively. Maximum and minimum ranges for relative humidity (%) were as follows: 42-100 and 8-59 during Jan, 49-95 and 11-39 during Feb, 33-96 and 11-50 during 1 to 10 Mar, respectively. Monthly rainfall (inches) in Jan, Feb, and 1 to 10 Mar were as follows: 0.14, 0.00, 0.44. Disease severity was recorded once on 9 - 10 Mar by determining the percentage of leaves with chlorosis and necrosis present within each of two 1-ft^2 areas within each of the three replicate plots per treatment using a rating scale from 0 to 4, where 0 = no symptoms (0% disease severity), 1 = 1 to 25% of plant leaves showing chlorosis and necrosis, 2 = 26 to 50%, 3 = 51 to 75%, and 4 = 76 to 100% with chlorosis and necrosis. The average number of spinach leaves in a 1-ft^2 area of bed was approximately 400. Disease ratings were converted to percentage values (midpoints), subjected to analysis of variance (ANOVA), and then compared with Bonferroni test (adjusted $P \leq 0.0025$).

Of the nine treatments that provided a statistically significant reduction in severity of downy mildew compared to control plants sprayed with water, four provided complete protection of spinach leaves (Blockade, Revus, Zampro, and Ranman + Silwet had no downy mildew). The next most effective treatments, in order of increasing severity of downy mildew, included Aliette, Mildicut at the higher rate of application, Nordox, Biospecific, and Timorex. With commercial baby-leaf spinach production, tolerance for leaves infected with downy mildew is extremely low. Considering this high benchmark of disease control, the only effective fungicides in the trial were the conventional fungicides Aliette, Blockade, Ranman, Revus, and Zampro, none of which is certified for organic production. Products certified for organic production that reduced downy mildew to levels less than that of the control plots included Nordox, Biospecific, and Timorex Gold. However, spinach leaves treated with Nordox had a highly visible, rusty, brown residue on the leaf surface. None of the treatments caused symptoms of phytotoxicity.

Treatment and rate of product/A [z]	Downy mildew rating[y]
Blockade 50WG 0.75 oz	0 d[x]
Revus 250SC 8.0 fl oz	0 d
Zampro 525SC 14.0 fl oz	0 d
Ranman 400SC 2.75 fl oz Silwet L-77 2.0 fl oz	0 d
Aliette 80WDG 5.0 lb	2.1 d
Mildicut 275SC 40.0 fl oz	18.8 cd
Nordox 75WG 2.0 lb	18.8 cd
Biospecific [w]	25.0 bc
Timorex Gold 20.2 fl oz	25.0 bc
Actinovate AG 12.0 fl oz	33.3 a-c
Double Nickel LC 1.0 qt	33.3 a-c
Mildicut 275SC 30.0 fl oz	33.3 a-c
T-22HC 2.0 lb	37.5 a-c
Cueva 2.0 gal	37.5 a-c
Serenade Max 46.0 fl oz	37.5 a-c
GWN-10320 28.0 fl oz	41.7 ab
Sea Shield 3.5 gal	41.7 ab
Oxidate 2.0 2.0 qt Aquasil 4.5 fl oz	45.8 ab
Water control	50.0 a
Oxiphos 4.0 qt	54.2 a

[z] Treatments were applied to foliage of plants on 6, 16, and 23 Feb. Downy mildew was first visually detected in plots on 10 Feb, between the first and second applications of products.

[y] Downy mildew ratings were recorded on 9-10 Mar.

[x] Means followed by a different letter are significantly different according to the Bonferroni test (adjusted $P \leq 0.0025$).

[w] Rates applied for the first, second, and third applications were 96, 77, and 35 gal/A, respectively.