SPINACH SEED CROP (*Spinacia oleracea*)
Cladosporium leaf spot; *Cladosporium variabile*
Stemphylium leaf spot; *Stemphylium botryosum*

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Evaluation of fungicides for control of leaf spot in spinach seed crops, 2003.

Fungicides were evaluated for control of leaf spot in a hybrid spinach seed crop trial established on a Puget silt loam soil at the Washington State University Mount Vernon REU. The field site was fumigated prior to seeding with Tri-Con 57/43 (methyl bromide/chloropicrin) at 350 lb/A to a depth of 8 in. on 30 Apr 03, and sealed with plastic tarp, for control of Fusarium wilt caused by *Fusarium oxysporum* f. sp. *spinaciae*. The tarp was cut on 5 May to release fumes, and removed on 8 May. Male and female stock seed of a proprietary spinach hybrid were planted on 19 May at a ratio of two male rows for every six female rows, with 22 in.-spacing between rows and 2 in.-spacing within rows. Fertilizer (18-46-0) was applied in-furrow (425 lb/A) at planting. The trial was tilled between rows and side-dressed with 34-0-0 (100 lb/A) on 18 Jun. The crop was hand-weeded and rogued on 1, 2, 7, 8, and 9 Jul. Plots, 20 ft-long and consisting of six female and two male rows, were established in the field on 3 Jul 03 with 15 ft alleys separating plots at each end. The experiment was arranged in a randomized complete block design with five replications. Fungicide applications were made on 10 (start of anthesis) and 22 Jul, and 13 and 28 Aug, in 44.5 gal/A at 40 psi using a CO_2-pressurized tractor-mounted sprayer fitted with a 7 nozzle boom (8003 flat fan tips at 20-in. spacing). R-11 surfactant was used with all fungicide applications at 1.0 pt/100 gal. Control plots were sprayed with water and R-11. Each plot was inoculated with 0.7 L of a pooled spore suspension of *C. variabile* and *S. botryosum* in 0.01% Tween 80 on 11 Jul (3.1×10^4 and 3.3×10^3spores/ml, respectively), 22 Jul (2.3×10^4 and 3.7×10^3 spores/ml, respectively), 6 Aug (4.7×10^3 and 6.3×10^3 spores/ml, respectively), 13 Aug (5.6×10^3 and 1.5×10^3 spores/ml, respectively), and 26 Aug (8.0×10^3 and 6.7×10^3 spores/ml, respectively) using a hand-held sprayer with a 110° flat-fan nozzle. To enhance leaf wetness, each plot was sprayed with water immediately prior to each inoculation, using the same tractor-mounted spray equipment at the rate and pressure described above. The crop was irrigated with an overhead sprinkler on 21 Jul and 1 Aug, with approximately 0.5 in./irrigation. Curzate 60 DF (3.2 oz/A) was applied 19 Aug for downy mildew control. Male rows were removed from all plots by hand on 28 Aug. The middle 5 ft of the center four female rows were cut by hand from each plot on 9 Sep. Harvested plants were placed onto 10 x 12 ft sections of Remay and transported to covered storage to dry. Plants were threshed on 30 Sep, and the seed cleaned and sized according to commercial specifications for the proprietary hybrid. Severity of leaf spot was assessed on 15 and 27 Aug, and 3 Sep. In Oct, a modified deep-freeze blotter assay was used to determine the incidence of *Stemphylium*, *Cladosporium*, and other fungi in 100 seed/plot. The seed was surface-sterilized for 1 min in 0.6% NaOCl, triple-rinsed in sterile deionized water, and placed onto damp blotters in plastic Petri plates (20 seed/plate). The seed imbibed on the blotters in the dark for 24 h, was incubated at –4 ºF for 24 h, and then at 75ºF under a 12h near-UV/12h dark light cycle. The seed was examined using a dissecting microscope (8 to 100x magnification) approximately 5, 10, and 14 days after plating. Germination of 100 seeds/plot was assessed according to the AOSA (Association of Official Seed Analysts) protocol. Mean temperature and total rainfall for Apr, May, Jun, Jul, Aug, and Sep were 49.4°F and 3.55 in., 54.3°F and 0.97 in., 61.3°F and 0.07 in., 64.7°F and 0.00 in., 63.1°F and 0.57 in., 59.8°F and 1.28 in. respectively.

Pristine EG, Cabrio EG, Sovran, Amistar, and Rovral 4F provided the best control of leaf spot, reducing the mean severity of leaf spot from 19% for control plots to ≤2%. These fungicides had greater efficacy against leaf spot than Bravo WS and Dithane DF, the primary fungicides currently used by spinach seed growers in the Pacific Northwest for control of leaf spot. There were no significant differences in seed yield and seed germination among fungicide treatments. However, the incidence of seedborne *S. botryosum* and *C. variabile* differed significantly among treatments. All fungicides, except Topsin M 70WP, significantly reduced the incidence of seedborne *S. botryosum* compared to control plots. All fungicides reduced the incidence of seedborne *C. variabile*. The correlation between severity of leaf spot on foliage on 3 Sep and incidence of seedborne *S. botryosum* and *C. variabile* was highly significant (0.81 and 0.57, respectively). Sovran, Amistar, Pristine EG, and Cabrio EG were the most effective at reducing seed infection by *S. botryosum*. The predominant leaf spot symptoms in the field were of Stemphylium leaf spot, which was reflected by the higher incidence of seedborne *S. botryosum* compared to *C. variabile*.

Treatment and rate/A	Severity of leaf spot (% on 3 Sep 03)[z]	Seed yield (g/37 ft^2)[y]	% Seed infected[x]	
			Stemphylium botryosum	*Cladosporium variabile*
Control (water) …….....	19.38 a[w]	831 a	23.6 a	9.0 a
Topsin M 70WP 1.5 lb …….....	12.00 b	787 a	19.6 a	0.6 bc
Manex 1.6 qt ……	7.70 c	939 a	11.6 b	3.8 b
Bravo WeatherStik 3.0 pt …….	5.50 d	757 a	11.2 bc	2.8 bc
Dithane DF Rainshield 2.0 lb …..	5.30 d	807 a	8.8 bcd	3.8 b
Rovral 4F 2.0 pt ……..…	2.10 e	740 a	6.2 bcd	3.8 b
Amistar 5.0 oz ……..	1.90 e	776 a	4.4 d	0.2 c
Sovran 4.8 oz ……	1.30 e	652 a	3.6 d	1.8 bc
Cabrio EG 1.0 lb ……..	1.25 e	1,037 a	6.0 cd	0.4 c
Pristine EG 0.7 lb …….	1.00 e	850 a	5.8 cd	0.2 c

[z] Severity of leaf spot rated as % foliage/plot with symptoms of Cladosporium leaf spot and/or Stemphylium leaf spot.
[y] Plants were harvested from a 5'-long section of the center four rows/plot (= 37 ft^2). Seed yield = g of marketable seed (between screen sizes 6.5 and 11).
[x] Mean % of 100 seed infected/plot. Seed assayed using a modified freeze/blotter assay described in the text above.
[w] Means followed by different letters in the same column are significantly different based on Fisher's Protected LSD (P≤0.05).