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

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Evaluation of spinach varieties for downy mildew resistance, 2015.

Downy mildew is the most economically important disease of spinach. Organic spinach production in California and Arizona comprises approximately 40% of total production in the USA. Thus, resistance is a critical tool for downy mildew management. 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%). A total of 68 spinach cultivars were evaluated for disease reactions to downy mildew. The spinach cultivar Viroflay, susceptible to all known races of the spinach downy mildew pathogen, was planted in border rows surrounding the entire trial. The plots were sprinkler-irrigated to germinate 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/A. Treatments were replicated three times in a randomized complete block design. Each replicate plot consisted of a 10 ft length of bed. Maximum and minimum air temperature ranges (°F) were as follows: 54-81, 27-56 during Jan; 70-88, 40-58 during Feb; 62-84, 42-58 during 1 to 10 Mar. Maximum and minimum ranges (%) for relative humidity were as follows: 42-100, 8-59 during Jan; 49-95, 11-39 during Feb; 33-96, 11-50 during 1 to 10 Mar. Monthly rainfall in inches was as follows: Jan, 0.14; Feb, 0.00; 1 to 10 Mar, 0.44. Disease was evaluated on 10 Mar by harvesting the leaves within each of two randomly selected 1-ft^2 areas within each of the three replicate plots per cultivar. The average number of spinach leaves in a 1-ft^2 area of bed was approximately 400 and approximately 800 leaves were evaluated per replication for each cultivar. Leaves were returned to the laboratory and individually rated on a scale from 0 to 4, where 0 = no symptoms (0% disease severity), 1 = 1 to 25% of the leaf surface with downy mildew symptoms of chlorosis and necrosis, 2 =26 to 50% with chlorosis and necrosis, 3 = 51 to 75% with chlorosis and necrosis, and 4 = 76 to100% with leaf chlorosis and necrosis. Analysis of variance (ANOVA) was performed on the data using R programming language on the two traits of disease severity and arcsine transformed disease incidence and the means of DS and DI of these varieties were compared using the least significant difference test ($p<0.05$) .

Downy mildew was first observed in plots on 10 Feb. A wide range of disease severity (2.1 to 35.2) and disease incidence (0.06 to 0.86) was determined for the collection of varieties evaluated. This was a baby-leaf spinach planting, where tolerance for leaves infected with downy mildew would be extremely low (typically less than 3%) in a commercial planting. All cultivars evaluated developed some level of disease, with the lowest disease incidence being 6%. Based on the genetic background of resistance in the cultivars evaluated, it was likely that pathogen races 10, 13, 14, and 15 were present in the naturally infested field plots and none of the varieties tested had resistance to all of the races present.

Variety	Disease severity[z]	Disease incidence[y]	Variety	Disease severity	Disease incidence
Red Kitten	35.2 a[x]	0.86 a	Ashley	11.3 d-l	0.39 d-q
El Ruedo	33.6 ab	0.80 ab	El Rancho	10.7 e-l	0.35 e-q
Kookaburra	31.8 a-c	0.86 a	El Tajin	10.4 f-l	0.48 b-o
SV2157VB	22.7 b-d	0.58 a-i	XSPK356	10.1 f-l	0.37 e-q
Gazelle	22.2 b-e	0.69 a-e	Bassoon	9.9 f-l	0.40 d-q
Spiros	20.7 c-f	0.53 a-l	Tasman	9.8 f-l	0.42 c-o
Raccoon	20.3 c-g	0.53 a-l	Tambourine	9.7 f-l	0.49 b-o
Remake	18.8 d-h	0.58 a-i	Escalade	9.7 f-l	0.42 c-o
Donkey	17.9 d-i	0.78 a-c	Silverwhale	9.5 f-l	0.34 f-q
Seaside	16.9 d-i	0.55 a-k	Banjo	9.5 f-l	0.40 d-q
PV-1390	16.8 d-i	0.59 a-i	Stanton	9.4 f-l	0.33 f-q
Lanazarote	16.6 d-i	0.64 a-f	Oceanside	9.2 f-l	0.36 e-q
Cello	16.1 d-j	0.57 a-i	Camaro	9.2 f-l	0.36 e-q
Bright Toucan	15.7 d-k	0.65 a-f	Avenger	9.0 g-l	0.42 c-o
Lakeside	15.6 d-k	0.56 a-j	PV-1028	8.9 g-l	0.31 g-q
Guitar	15.5 d-k	0.72 a-d	SV1846VC	8.4 h-l	0.35 e-q
Responder	15.2 d-k	0.63 a-g	EO3D.0808	8.4 h-l	0.34 f-q
Riverside	14.9 d-k	0.55 a-k	Carmel	7.9 h-l	0.35 f-q
Yukon	14.8 d-k	0.62 a-h	51-710RZ	7.4 h-l	0.18 n-q
Amazon	14.4 d-k	0.53 a-l	SV2146VB	7.2 h-l	0.37 e-q
Reflect	14.1 d-k	0.52 b-m	Renegade	7.1 h-l	0.34 f-q
PV-1135B	14.0 d-k	0.48 b-o	LDSD 948	7.1 h-l	0.36 e-q
Caladonia	13.7 d-l	0.60 a-i	Marabou	6.7 i-l	0.33 f-q
Piano	13.6 d-l	0.51 b-n	Mandolin	6.7 i-l	0.30 h-q
Hudson	13.5 d-l	0.48 b-o	PV-1029	6.4 i-l	0.28 i-q
Molokai	13.4 d-l	0.63 a-h	Whale	6.1 i-l	0.23 j-q
Pacer	13.3 d-l	0.55 a-k	Shelby	6.0 i-l	0.22 k-q
Violin	13.1 d-l	0.47 b-o	Bongo	5.8 i-l	0.23 j-q
Hybrid SL	12.8 d-l	0.37 e-q	51-343RZ	5.8 i-l	0.18 m-q
El_Real	12.6 d-l	0.57 a-i	Meerkat	5.5 i-l	0.17 o-q
XSPK353	12.6 d-l	0.44 c-o	Castanet	4.5 j-l	0.18 n-q
Revere	12.1 d-l	0.41 c-p	51-338RZ	4.4 jkl	0.20 l-q
Yabi	12.0 d-l	0.49 b-o	Coati	4.0 kl	0.17 o-q
Woodpecker	11.5 d-l	0.29 h-q	Platypus	2.1 l	0.06 q

[z] Disease incidence (DI) was calculated as follows: DI = (B+C+D+E) / (A+B+C+D+E), where A, B, C, D, and E = # of leaves with a score of 0, 1, 2, 3, or 4, respectively.

[y] Disease severity (DS) was calculated using the midpoint of each category, for example, the midpoint for a rating of 1 (1-25%) was 12.5. DS = [(A*0) + (B*12.5) + (C*37.5) + (D*62.5) + (E*87.5)] /(A+B+C+D+E).

[x] Variety means with the same letter are not significantly different as determined by Fisher's LSD test (P=0.05). The LSD for disease severity was 11.7 and for disease incidence was 0.34.