

# Evaluation of Radish Cultivars for Resistance to Scab Caused by *Streptomyces scabies*

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## ABSTRACT

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Eighty radish cultivars from the United States and Europe were evaluated in two field trials for resistance to radish scab caused by *Streptomyces scabies*. White elongate (icicle) cultivars showed consistently less scab than red globe cultivars. A European cultivar, Sar Katra, was the only red globe cultivar exhibiting significantly greater tolerance to scab than an American standard cultivar, Scarlet Knight. Horticultural characteristics and lack of resistance to Fusarium yellows, however, make it unsuitable for use in this country.

**Table 1.** Scab incidence on American radish cultivars (first 1979 field trial)

Cultivar <sup>a</sup>	Scabbed radishes <sup>b</sup> (%)	Yield (kg) <sup>c</sup>
Inca	88 a	0.83
Red Boy	82 ab	1.22
Comet	82 ab	1.08
Champion	81 ab	1.46
Scarlet Knight	79 ab	1.19
Red Devil B	76 abc	1.06
Cherry Belle 6D	74 abc	1.28
Fuego	74 abc	0.89
Red Devil	73 abc	1.20
Fancy Red	67 bcd	0.82
Red Prince	63 bcd	0.94
Far Red	58 cd	0.88
Scarlet Turnip		
White Tipped	58 cd	0.84
Icicle Short Top	46 d	1.49

<sup>a</sup> Icicle Short Top is a white elongate cultivar; Scarlet Turnip White Tipped is a red/white globe; all others are red globes.

<sup>b</sup> Percentages with same letters are not significantly different at  $P = 0.05$  according to Duncan's multiple range test.

<sup>c</sup> Mean weight of radishes harvested from the center 3 m of a single replicate row (about 100 radishes).

Radish scab caused by *Streptomyces scabies* (Thaxt.) Waksman & Henrici can be an economically important disease in commercial radish production (2,3). In many midwestern states, radishes are grown on valuable muck soil, which necessitates consistently high yields in order to maintain suitable profit margins. Since 1978, several Michigan radish growers have experienced heavy losses caused by scab. Infection levels have exceeded 50% in many fields and in one instance over 20% of the acreage has been removed from radish production because of the disease.

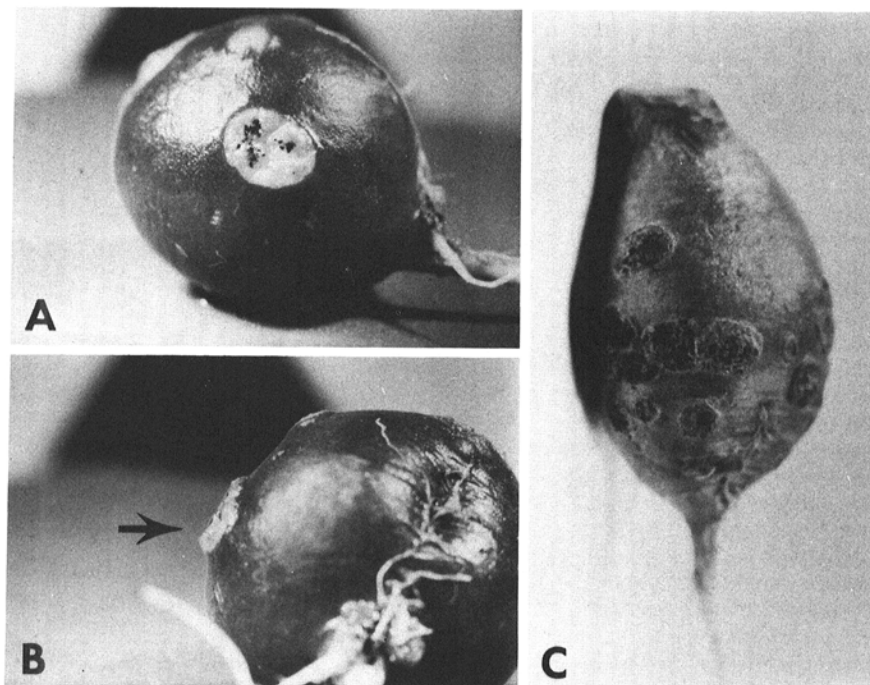
Symptoms of radish scab appear after hypocotyl enlargement begins as small, whitish-gray, scalelike spots, about 1 mm in diameter. Circular lesions develop from these spots, often reaching 1–1.5 cm in diameter by harvest (5). The edges of the lesions are raised, forming a lip, while the centers are sunken and pitted (Fig. 1A and B). These centers appear white in younger lesions but the activity of secondary organisms causes discoloration, softening, or rotting of the exposed tissue (Fig. 1C). Infected radishes are unsalable with even a single lesion.

*S. scabies* is well known as the cause of a similar disease on potato (1,5). The purpose of this study was to evaluate a number of American and European radish cultivars for resistance to *S. scabies*.

## MATERIALS AND METHODS

Field trials were carried out at a commercial radish farm near Gregory, MI, during 1979 and 1981. The farm had produced turfgrass for many years before switching to radish production in 1976. The soil was composed of a homogenous Carlisle peat (pH 6–6.5) and the plots used for this study had a recent history of severe scab.

In each plot, the soil was cultivated with a disk harrow, rolled, and treated with an ammonia-based 6-24-24 fertilizer supplemented with manganese. Fonofos 10G (2.24 kg/ha) was applied in the row at planting in 1979 for control of cabbage maggot (*Hylemya brassicae* (Wiedmann)). Diazinon 14G (2.24 kg/ha) was applied in



**Fig. 1.** Symptoms of radish scab (*Streptomyces scabies*): (A) Typical lesion with pitted center. (B) Side view of lesion in (A) showing raised borders (arrow). (C) Severely scabbed radish with lesions discolored and rotting due to invasion by secondary organisms.

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the row at planting in the 1981 trial. Seeds were planted with a V-belt hand-pushed planter at 10 seeds per 30 cm of row, 4.6 m of row per cultivar per replicate, with a spacing between rows of 46 cm. At harvest, the center 3 m of each row was hand-pulled; the radishes were topped, washed, weighed, counted, and the percentage of infected radishes was determined.

In 1979, two field trials were conducted. In the first trial, 14 American cultivars and 11 European and experimental cultivars were compared for relative resistance to scab. A completely randomized design was used with six replicate rows for each of the American

**Table 2.** Scab incidence on experimental and European radish cultivars tested in the first 1979 field trial

Cultivar <sup>a</sup>	Scabbed radishes (%)	Yield (kg) <sup>b</sup>
Kutura Hybrid*	100	1.13
Saxa-Treib	95	1.05
Gaudry*	90	0.82
Carnita	90	1.11
Parat	90	1.21
Real	85	0.99
Exp CHPR/3808	85	0.71
Saxafire	83	0.82
Scharo	80	0.84
Rico**	65	1.10
Exp PRA/3398-3408	55	0.87

<sup>a</sup>Cultivar names followed by (\*) are red/white globe, (\*\*) are red/white elongate types, all others are red globes.

<sup>b</sup>Mean weight of radishes harvested from the center 3 m of a single replicate row (about 100 radishes).

**Table 3.** Scab incidence on American radish cultivars (second 1979 field trial)

Cultivar <sup>x</sup>	Scabbed radishes <sup>y</sup> (%)	Yield (kg) <sup>z</sup>
Champion	92 a	1.62
Exp PRA/3398-3408	90 ab	1.44
Scarlet Knight	90 ab	1.33
Red Devil B	89 abc	1.64
Red Devil	87 abc	1.40
Fuego	86 abc	1.09
Scarlet Turnip		
White Tipped*	85 abcd	1.21
Fancy Red	84 abcd	0.91
Far Red	84 abcd	0.56
Cherry Belle 6D	83 bcde	1.32
Red Boy	77 cdef	1.01
XP 3568**	72 def	1.41
XP 3778**	70 ef	1.31
White Icicle**	70 ef	1.04
Icicle Short Top**	69 f	1.44
XP 3728**	63 f	1.47

<sup>x</sup>Cultivar names followed by (\*) are red/white globe, (\*\*) are white elongate, all others are red globes.

<sup>y</sup>Percentages with same letters are not significantly different at  $P=0.05$  according to Duncan's multiple range test.

<sup>z</sup>Mean weight of radishes harvested from the center 3 m of a single replicate row (about 100 radishes).

**Table 4.** Scab incidence on European and American radish cultivars (1981 field trial)

Cultivar <sup>x</sup>	Origin	Scabbed radishes <sup>y</sup> (%)	Yield (kg) <sup>z</sup>
E 2353	Holland	83 a	0.67
Novitas	Holland	73 ab	0.89
Flevo	Holland	71 abc	0.48
French Breakfast-I*	Holland	70 abc	0.76
Neoro	Holland	69 abc	0.91
Rondeel	Holland	69 abc	0.80
Robijn	Holland	69 abc	0.96
Americano	Holland	68 abc	0.55
Saxa-I	Germany	66 abcd	0.94
Scharo	Holland	65 abcd	0.57
Flamboyant*	France	65 abcd	0.82
Round Red Forcing Minitas	England	62 abcde	0.58
Bicolor**	Holland	60 abcdef	0.76
Saxa Korto	Denmark	60 abcdef	0.54
Revosa-I	Holland	60 abcdef	0.53
Scarlet Globe	Holland	59 abcdef	0.60
French Breakfast-II*	England	59 abcdef	0.35
Champion-I	Holland	59 abcdef	0.74
Revosa-II	England	57 abcdefg	0.17
Saxa-II	England	56 bcdefg	0.48
Subliem	Holland	55 bcdefg	0.77
Columbia**	Holland	55 bcdefg	0.37
Fota*	Denmark	54 bcdefgh	0.93
French Breakfast-III*	Holland	54 bcdefgh	0.39
Claro	Denmark	53 bcdefgh	0.52
Pink Beauty	Holland	53 bcdefgh	0.50
Rota	England	53 bcdefgh	0.57
Champion-II	England	52 bcdefgh	0.87
Riesenbutter***	Holland	52 bcdefgh	1.12
French Breakfast Large Tipped White*	England	52 bcdefgh	0.64
Verano	Holland	52 bcdefgh	0.56
Prinz Rotin	Germany	51 bcdefgh	0.67
E 2358	Holland	51 bcdefgh	0.93
Novired	Holland	50 bcdefgh	0.70
RS 1004	Holland	50 bcdefgh	0.90
Eroica	Holland	49 bcdefgh	0.59
Half Rod/ Half Witte**	Holland	49 bcdefgh	0.37
Inca	Holland	48 bcdefgh	0.68
Sparkler-I**	Holland	48 bcdefgh	0.54
Daagse Halflunge			
Rode Witpont*	Holland	48 bcdefgh	0.73
Cherry Belle-I	England	48 bcdefgh	0.36
Saxerre	France	48 bcdefgh	0.58
Ronde Rode Kleinwitpunt	Holland	48 bcdefgh	0.48
Scarlet Knight	United States	48 bcdefgh	0.49
Bamba*	France	48 bcdefgh	0.74
Qum Kader	Holland	47 bcdefgh	0.61
Sparkler-II**	England	46 bcdefgh	0.42
Fakir**	France	46 bcdefgh	0.29
Crimson Giant	Holland	45 bcdefgh	0.68
Cherry Belle-II	Holland	44 bcdefgh	0.58
Ronde Witte Roodkop**	Holland	44 bcdefgh	0.67
Ribella	Holland	43 cdefgh	0.60
Delia*	Denmark	43 cdefgh	0.43
Rubinova	Denmark	43 cdefgh	0.36
Goya*	France	36 defgh	0.41
Piggelmee	Holland	36 defgh	0.55
Cherry Belle-III	Holland	33 efghi	0.72
Scarabelle	Holland	33 efghi	0.57
Middle East Giants	Holland	33 efghi	1.12
Icicle****	Holland	32 efghi	0.66
Icicle Short Top****	United States	31 fghi	0.85
Parat	Germany	31 fghi	0.79
Carnita	Germany	28 ghi	0.47
Long White Icicle****	Holland	25 hij	0.98
Sar Katra	Holland	12 ij	0.51
Lange Scharlakenrode***	Holland	9 j	0.38

<sup>x</sup>Cultivar names followed by (\*) are red/white elongated, (\*\*) are red/white globe, (\*\*\*) are red elongate, (\*\*\*\*) are white elongate, all others are red globes. Roman numerals following cultivar names denote identical cultivars from different seed companies.

<sup>y</sup>Percentages with same letters are not significantly different at  $P=0.05$  according to Duncan's multiple range test.

<sup>z</sup>Mean weight of radishes harvested from the center 3 m of a single replicate row (about 50 radishes).

cultivars and either one or two replicate rows for each of the other cultivars because of limited seed availability. Mature radishes were harvested and processed as described previously after 33 growing days. The second trial compared 12 of the cultivars from the previous planting and four experimental white cultivars in an identical plot design using six replicate rows per cultivar. Mature radishes were harvested after 33 days.

In 1981, 64 radish cultivars obtained from European seed companies were compared with two American cultivars, Scarlet Knight (a red globe cultivar) and Icicle Short Top (an elongate white cultivar), in a randomized block design with three replicates. The radishes were harvested after 28 growing days.

Analyses of variance, including Duncan's multiple range tests, were conducted on transformed percentage data (arc sine).

## RESULTS

All radishes harvested in these experiments were of commercially acceptable size except Far Red, which was small by commercial standards. Seed germination ranged as low as 25% for some of the European cultivars, which accounts for the relatively low yields. The number of lesions per diseased root ranged from one to 15 and averaged four in all of the trials. The range in lesion size was constant, regardless of cultivar or horticultural type.

The American red globe cultivars tested in 1979 were highly susceptible to scab and differed little in percent infection. In the first 1979 trial, Icicle Short Top, the only elongate white cultivar tested, had the lowest scab incidence (46%) compared with the red globe cultivars, which ranged from 58 to 88% infection (Table 1). The percentage of diseased radishes for the 11

experimental and European cultivars ranged from 55 to 100% (Table 2).

In the second 1979 trial, infection for the red globe cultivars ranged from 78 to 92%, while the elongate white cultivars ranged from 63 to 78% infected (Table 3). An analysis of percent infected radishes by horticultural type indicated that the elongate white cultivars were significantly less scabbed than the red globe cultivars ( $P = 0.01$ ).

In the 1981 trial, Sar Katra was the only European red globe cultivar with significantly less scab than the American red globe cultivar Scarlet Knight (Table 4). None of the European elongate white or red/white hybrids were significantly less scabbed than the American elongate white cultivar Icicle Short Top. Lange Scharlakenrode, an elongate red cultivar, had significantly less scab than both American cultivars.

## DISCUSSION

None of the cultivars tested in 1979 were highly resistant to scab, although the elongate white cultivars displayed consistently lower levels of disease than the red globe cultivars. Unfortunately, the market demand for white radishes is relatively low, so commercial use seems unlikely.

Work by Rowe (4) indicated that, although most American radish cultivars are susceptible to clubroot (*Plasmodiophora brassicae* Wor.), many European cultivars are highly resistant. Because *S. scabies* has been reported to be endemic in European radish growing areas (2) and scab does not appear to be a major problem there, European cultivars were tested for resistance to scab. In 1979, none of the European cultivars tested were highly resistant to scab, although a meaningful statistical analysis of the data was not possible. In 1981, Sar Katra was the only European red globe cultivar that

appeared highly resistant to scab; however, it is not likely to be accepted by American commercial growers because of its pale color and tendency to elongate. In addition, resistance to *Fusarium yellows*, which is carried by most American cultivars, is lacking in European cultivars. For similar reasons, the elongate red cultivar Lange Scharlakenrode cannot be considered for use in this country. The low germination observed in European cultivars may be due to sensitivity of these cultivars to the environmental conditions under which the trial was conducted.

Further varietal testing is necessary to identify germ plasm carrying scab resistance. Tests should be expanded to include a number of cultivars available from the Orient as well as comparisons of cultivars under various environmental conditions and soil types. The elucidation of the factors that make elongate white cultivars more resistant to scab may aid in future breeding programs. At present, however, radish scab must be controlled through alternative methods, such as the exclusion of the pathogen from uninfested soils or the planting of an alternate, nonsusceptible crop.

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