Reduction in White Rot Incidence by Seed Irradiation in *Allium cepa*

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ABSTRACT

Utkhede, R. S., and Rahe, J. E. 1982. Reduction in white rot incidence by seed irradiation in *Allium cepa*. Plant Disease 66:723-725.

Plants grown from gamma-irradiated seeds of the open-pollinated onion cultivar Ailsa Craig were evaluated for infection by *Sclerotium cepivorum*, the causal agent of white rot, in 1978. Percentage of infection was significantly less in progenies from treated seeds compared with those from untreated control seeds. Similar results were obtained in 1979 with the cultivar Ailsa Craig and the hybrid cultivar Autumn Spice. Significant reduction in percentage of infection of selfed and open-pollinated M_2 progenies of irradiated seeds of the cultivar Ailsa Craig was observed in 1980.

White rot, caused by *Sclerotium cepivorum* Berk., is restricted to *Allium* spp. and is of long-standing, worldwide distribution (15). Resistance to *S. cepivorum* has been reported for some commercial cultivars and accessions to the USDA world onion germ plasm collection (5,12–14), but immunity to *S. cepivorum* in *A. cepa* L. is unknown. Gamma irradiation has been used to induce mutation toward resistance to some pathogens (4,6–11), but no attempts to create mutation towards resistance to white rot in onions have been reported. This paper describes the effect of irradiation on incidence of white rot in commercial onion cultivars.

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Accepted for publication 6 November 1981.

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0191-2917/82/08072303/$03.00/0

MATERIALS AND METHODS

All evaluations were carried out as field trials at Burnaby, British Columbia, on muck soil situated on a market vegetable farm on which white rot had previously occurred. All trials were established on an experimental plot that was heavily infested with sclerotia of *S. cepivorum* originating from infected onions grown yearly on the plot since 1976. The experimental plot was rototilled twice and formed into raised beds each year. Soil pH in the trial field was 5.2 (determined on a thick suspension of soil in 0.01 M calcium chloride).

Meteorologic data were recorded in the center of the field. Air temperatures (30 cm above ground) during the trials ranged from 6 to 32 C, 5 to 30 C, and 8 to 21 C in 1978, 1979, and 1980, respectively. The soil temperatures (10 cm below the surface) ranged from 10 to 25 C, 10 to 23 C, and 11 to 21 C in 1978, 1979, and 1980, respectively. From May through September, the mean daily ranges for air temperatures were 10 to 20 C, 15 to 18 C, and 8 to 18 C in 1978, 1979, and 1980, respectively. The mean daily ranges for soil temperatures were 15 to 18 C, 11 to 21 C, and 13 to 17 C in 1978, 1979, and 1980, respectively. Rainfall totaled 290, 196, and 520 mm with daily averages of 3.1, 1.5, and 4.1 mm from May through September in 1978, 1979, and 1980, respectively.

1978 Field trial. Seeds of the open-pollinated cultivar Ailsa Craig (seed purchased in 1978) were irradiated at doses of 4, 8, 12, 16, and 20 kR from a cobalt 60 source 4 days prior to seeding and planted in randomized complete block design with three replicates. The individual treatment plots contained five rows 1.25 m long, spaced 25 cm apart, and double seeded at 7-cm spacing. The trial was seeded on 11 May and harvested on 14 September 1978. All data were collected from the middle three rows only. Bulbs apparently free of white rot at harvest were retained for producing seeds in 1979.

1979 Field trial. Seeds of the open-pollinated cultivar Ailsa Craig and the hybrid cultivar Autumn Spice (both purchased in 1979) were irradiated at doses of 2, 4, 12, and 20 kR 4 days prior to seeding. The trial was conducted in a randomized complete block design with three replicates. The individual treatment plots consisted of five rows 1.75 m long, but otherwise the same as described for the 1978 trial. The trial was seeded on 24 April and harvested on 13 September 1979.

In 1979, the resistant bulbs from the 1978 trial were planted. Some individual plants were selfed, and open pollination of the remaining flowers was allowed. The selfed and open-pollinated seeds were collected for testing in 1980.

1980 Field trial. Six selfed and open-pollinated progenies, along with seeds of the 1978 parent seed lot and Autumn Spice as control cultivars (seed purchased in 1980), were evaluated in a 3 × 3 simple lattice design. The trial was seeded on 2 May and harvested on 12 September 1980.

Fertilization, weed, and insect treatments were provided for the trials as prescribed for onions in the British Columbia Ministry of Agriculture Vegetable Production Guide (1) and were uniform for all treatments. Insecticide was used to control maggots. Percentage of infection was calculated from the difference between numbers of emerged plants and harvested bulbs apparently free of white rot as a percentage of the number of emerged plants. All results were analyzed for statistical significance; Duncan's multiple range test (2) and 5% level of significance were used to compare different treatments.

Table 1. Effect of irradiation on incidence of onion white rot in the cultivar Ailsa Craig, 1978

Treatment	Infection[w] (%)	Yield (ton/ha)	Emergence[x] (%)	Bulb weight[y] (g/bulb)
20 kR	5.2 a[z]	13.9 b	35.4 b	86.5 c
16 kR	16.1 ab	33.3 a	36.2 ab	139.9 b
12 kR	14.3 ab	33.8 a	42.3 ab	153.7 b
8 kR	11.9 ab	31.7 a	38.1 ab	140.3 b
4 kR	22.1 b	45.9 a	40.1 ab	216.2 a
Control	40.6 c	37.6 a	52.8 a	171.9 ab
SE	3.7	4.6	4.1	12.2

[w] Calculated from the difference between numbers of emerged plants and harvested bulbs apparently free of white rot as a percentage of the number of emerged plants.
[x] Percentage of maximum possible number (108) of plants emerged 3 wk after planting.
[y] Mean weight of individual healthy bulbs harvested for each treatment.
[z] Values within a column followed by the same letter do not differ significantly ($P = 0.05$) according to Duncan's multiple range test.

Table 2. Effect of irradiation on incidence of onion white rot in cultivars Ailsa Craig and Autumn Spice, 1979

Treatment	Infection[x] (%)	Bulb weight[y] (g/bulb)
	Autumn Spice	
20 kR	31.9 b[z]	106.1 bc
12 kR	43.0 c	111.8 bc
4 kR	63.4 e	116.6 bc
2 kR	64.6 e	122.7 ab
Control	63.1 e	82.9 c
	Ailsa Craig	
20 kR	48.8 c	24.9 d
12 kR	23.9 a	127.3 ab
4 kR	60.0 de	157.2 a
2 kR	53.5 cd	135.2 ab
Control	64.8 d	116.4 bc
SE	2.3	11.0

[x] Calculated from the difference between numbers of emerged plants and harvested bulbs apparently free of white rot as a percentage of the number of emerged plants.
[y] Mean weight of individual healthy bulbs harvested for each treatment.
[z] Values within a column followed by the same letter do not differ significantly ($P = 0.05$) according to Duncan's multiple range test.

Table 3. Effect of irradiation on incidence of onion white rot in the M_2 generation in the cultivar Ailsa Craig, 1980

Treatment	Infection[w] (%)	Yield (ton/ha)	Emergence[x] (%)	Bulb weight[y] (g/bulb)
12 kR open-pollinated	9.8 a[z]	26.7 a	41.2 a	163.6 ab
8 kR self	18.7 ab	15.6 bc	55.8 a	95.6 b
4 kR open-pollinated	19.3 ab	26.0 a	47.2 a	146.3 b
8 kR open-pollinated	24.8 bc	30.9 a	63.8 a	144.7 b
4 kR self	25.8 bc	15.7 bc	61.6 a	103.4 b
16 kR self	26.3 bc	22.4 ab	39.2 a	139.2 b
12 kR self	29.7 bc	15.4 bc	40.3 a	169.6 ab
Ailsa Craig (1978 parent)	36.1 c	5.8 c	44.3 a	159.7 ab
Autumn Spice (Buckerfield 1980)	74.7 d	14.4 bc	40.0 a	242.5 a
SE	3.6	3.0	8.4	26.0

[w] Calculated from the difference between numbers of emerged plants and harvested bulbs apparently free of white rot as a percentage of the number of emerged plants.
[x] Percentage of maximum possible number (250) of plants emerged 3 wk after planting.
[y] Mean weight of individual healthy bulbs harvested for each treatment.
[z] Means within a column followed by the same letter do not differ significantly ($P = 0.05$) according to Duncan's multiple range test.

RESULTS

Percentage of infection was significantly less in all M_1 progenies from gamma-irradiated seeds of the cultivar Ailsa Craig purchased in 1978 than in the nonirradiated control (Table 1). Percentage of emergence, yield, and size of bulbs were not significantly reduced by irradiation except for the 20 kR treatment.

Results of the 1979 trial generally confirmed those of the 1978 trial (Table 2). M_1 progenies of both Ailsa Craig and Autumn Spice were significantly more resistant to white rot than were the nonirradiated controls for treatments at 12 and 20 kR but not at 2 and 4 kR. Bulb weight was significantly reduced at the treatment level of 20 kR on Autumn Spice.

In the 1980 trial, all M_2 progenies of Ailsa Craig were significantly more resistant than the Autumn Spice control, and three M_2 progenies (open-pollinated at 4 and 12 kR; selfed at 8 kR) were significantly more resistant than the Ailsa Craig 1978 parent (Table 3).

DISCUSSION

Gamma irradiation of seeds of the open-pollinated cultivars Ailsa Craig and the hybrid cultivar Autumn Spice provided a significant reduction in the percentage of white rot in M_1 progenies. Significantly reduced percentage of infection over the 1978 Ailsa Craig parent was observed in selfed and open-pollinated M_2 progenies.

We have observed significant differences in the levels of resistance of different commercial seed lots of onion cultivars (eg, Ailsa Craig) to white rot and believe that, at present, resistance must be assigned to a seed lot rather than a cultivar (*unpublished observations*). Significant resistance to white rot does exist in *A. cepa*, and it can be increased to

useful levels by irradiation and recurrent selection.

We have not attempted to establish the mechanism of radiation-induced resistance to white rot. *Allium* spp. produce specific germination stimulants for sclerotia of *S. cepivorum* (3). We do not know whether irradiation causes mutations that result in reduced production of germination stimulants or whether it affects the tissue reaction of host plants to infection.

ACKNOWLEDGMENTS

This research was supported in part by funds from the British Columbia Ministry of Agriculture and Food, Agriculture Canada, and National Science and Engineering Research Council of Canada. The authors express appreciation to the Cloverdale Onion Growers Research Association for providing the field trial area and other forms of material support.

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