Green Leaf Lettuce Breeding Lines with Resistance to Corky Root, 06-831 and 06-833

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Corky root of lettuce (*Lactuca sativa* L.) has been found in major lettuce-producing regions of the world, including North America, Western Europe, Australia, and New Zealand. Roots of infected plants develop yellow to brown lesions that later become longitudinal corky ridges. Yield losses from reduced head size can reach 30% to 70% in severely infested fields in California and Florida (van Bruggen, 1997). The pathogen most commonly isolated from diseased roots is the bacterium *Sphingomonas suberifaciens* (Yabuuchi et al., 1999), formerly *Rhizomonas suberifaciens*, although several other bacterial species have also been isolated (van Bruggen, 1997). The incidence of corky root can be reduced by soil fumigation (O'Brien and van Bruggen, 1990) and by using lettuce transplants instead of direct-seeding (van Bruggen and Rubatzky, 1992). However, these practices may not be economically feasible for the Salinas Valley, CA, the major lettuce production area in the United States (Patterson et al., 1986). The use of cultivars resistant to *S. suberifaciens* has been an important management strategy for corky root. The resistance to corky root is controlled by a recessive allele (*cor*) at a single locus (Brown and Michelmore, 1988), which has been deployed in most resistant lettuce cultivars.

Although corky root resistance has been transferred into many crisphead lettuce cultivars, there are few leaf lettuce varieties with the resistance, especially for publicly released cultivars. With increasing consumption and production of leaf lettuce, there is a need for public germplasm that facilitates the research and development of new cultivars and germplasm. In this article, we describe two green leaf breeding lines with resistance to corky root and adaptation to the major lettuce production areas of the central coast of California.

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The breeding lines were derived from a cross between green leaf cultivar Waldmann's Green and crisphead cultivar Glacier that has *cor* alleles (Ryder and Waycott, 1994). Progeny plants were grown in a field with a history of corky root disease at the USDA Agricultural Research Station in Salinas, CA, and were selected for resistance to corky root and horticultural traits. Single plant selections were made by using the pedigree breeding method from F₂ to F₆ generations. 06-831 and 06-833 are F₇ breeding lines.

Fig. 1. Green leaf lettuce 06-831 in the field.

Fig. 2. Green leaf lettuce 06-833 in the field.

Table 1. Means of corky root rating for leaf lettuce breeding lines and cultivars grown in trials from 2007 to 2010 at Spence Farm, Salinas, CA.

Genotype	Type	Corky root ^{a,y}			
		2007	2008	2009	2010
Waldman's Green	Green leaf	8.0 a	8.0 a	8.0 a	7.9 ab
Shining Star	Green leaf	7.9 ab	8.0 a	7.9 ab	7.9 ab
Two Star	Green leaf	7.8 ab	7.9 a	7.7 b	7.4 bc
Lolla Rossa	Red leaf	7.7 abc	7.8 a	7.1 c	7.2 c
Big Red	Red leaf	7.5 bc	7.9 a	7.8 ab	7.8 ab
Redina	Red leaf	7.2 cd	6.9 b	6.7 c	7.2 c
Merlot	Red leaf	6.8 d	6.7 b	7.2 bc	6.9 c
Grand Rapids	Green leaf	—	8.0 a	8.0 a	8.0 a
Prizehead	Red leaf	—	7.9 a	7.9 a	7.8 ab
Glacier	Crisphead	5.4 e	5.9 c	5.7 d	5.7 d
06-831	Green leaf	5.7 e	5.6 c	5.9 d	5.6 d
06-833	Green leaf	5.3 e	5.4 c	5.4 e	5.5 d

^aCorky root ratings using Brown and Michelmore's (1988) scale of 0 to 9.

^yMeans with the same letter are not significantly different at $P < 0.05$. Plot means were analyzed by analysis of variance using the general linear model procedure of JMP Version 5 (SAS Institute, Cary, NC). Genotype was considered the fixed effect and replication was considered the random effect.

Table 2. Means of plant weight (g), core length (cm), and tipburn for leaf lettuce breeding lines and cultivars grown in trials from 2007 to 2010 at Spence Farm, Salinas, CA.

Genotype	2007			2008			2009			2010		
	Plant wt (g) ^z	Core (cm) ^y	Tipburn leaves ^x	Plant wt (g)	Core (cm)	Tipburn leaves	Plant wt (g)	Core (cm)	Tipburn leaves	Plant wt (g)	Core (cm)	Tipburn leaves
Waldman's Green	565.0 bcd	8.9 a	0.0 b	526.3 de	9.1 bc	0.0 b	393.7 c	9.1 ab	0.3 ab	285.3 cd	4.2 def	0.7 a
Shining Star	477.3 de	5.2 bc	0.0 b	690.8 c	7.6 cde	0.0 b	448.3 bc	7.2 bc	0.3 ab	399.0 bc	5.7 cd	0.1 a
Two Star	559.3 cd	4.5 c	0.0 b	736.3 bc	4.8 g	0.0 b	449.4 bc	5.1 cd	0.0 b	348.3 bc	4.4 def	0.1 a
Lolla Rossa	149.0 g	5.6 bc	0.0 b	217.5 g	7.2 cdef	0.0 b	110.7 e	2.6 e	0.0 b	86.1 d	3.3 f	0.0 a
Big Red	505.8 de	8.8 a	0.0 b	806.8 abc	13.2 a	4.0 a	333.7 cd	5.0 cde	0.5 ab	462.1 bc	8.3 ab	0.0 a
Redina	235.5 f	7.8 a	0.0 b	357.0 ef	10.6 b	0.0 b	306.2 cd	11.2 a	0.0 b	276.0 cd	8.4 a	0.0 a
Merlot	244.3 f	5.4 bc	0.0 b	326.8 fg	8.8 bc	0.0 b	257.7 de	4.3 de	0.0 b	276.2 cd	6.5 bc	0.0 a
Grand Rapids	—	—	—	421.5 de	5.0 fg	0.0 b	320.5 cd	4.9 cde	0.5 ab	336.8 bc	5.2 cde	0.8 a
Prizehead	—	—	—	690.5 c	5.9 defg	0.0 b	374.5 cd	4.3 de	0.3 ab	289.0 cd	3.4 ef	0.0 a
Glacier	654.3 abc	4.3 c	0.5 a	796.5 abc	5.1 fg	0.6 b	622.4 a	4.4 de	0.1 b	809.7 a	6.5 bc	0.0 a
06-831	688.8 a	5.8 bc	0.0 b	924.5 a	8.2 bcd	0.4 b	602.2 ab	6.8 bc	0.0 b	530.3 b	6.0 cd	0.8 a
06-833	665.5 ab	5.9 bc	0.0 b	851.5 ab	7.4 cdef	0.0 b	641.3 a	7.9 b	1.3 a	519.8 b	6.5 bc	0.3 a

^zMeans with the same letter are not significantly different at $P < 0.05$.

^yCore length from bottom of the plant.

^xNumber of leaves with tipburn per plant.

Description

The lines 06-831 and 06-833 look similar to 'Waldmann's Green' and related cultivars (Figs. 1 and 2). The green color extends close to the core. Leaf margins are mildly incised, indented, and undulated. The leaf surface is crinkled or blistered. Leaf width and length are approximately equal, but the leaf becomes narrower toward the base. Ribs are flat but become more pointed toward the base. Bases of outer and interior leaves overlap well. The texture is relatively soft and flexible. It has a mild and slightly sweet taste. Seed color is black.

Disease Resistance

The breeding lines, along with nine commercial leaf lettuce cultivars, were planted in trials at the Spence Farm of the Agricultural Research Service of the USDA, Salinas, CA, in the past 4 years with the following planting dates: 19 June 2007, 10 June 2008, 9 June 2009, and 16 June 2010. Cultivar Glacier was included in all trials as a resistant control. The experimental design was a randomized complete block with four replications. Each plot was 14 m long at the commercial spacing of 30 cm between plants and 35 cm between rows on a 1-m-wide double-row bed. Standard production practices were followed in these trials. At harvest maturity, the roots of three randomly selected plants from each plot were rated using Brown and Michelmore's (1988) scale of 0 to 9 (0, no disease symptom; 9, plant died from the disease). The corky root ratings of the breeding

lines were not significantly different from the resistant control 'Glacier' but were significantly lower than nine susceptible leaf lettuce cultivars in the trials (Table 1).

From field observations, the breeding lines were not resistant to downy mildew (*Bremia lactucae* Regel, data not shown). Other disease reactions have not been tested.

Performance and Adaptation

In the field trials mentioned, three randomly selected plants from each plot were cut at ground level and weighed. The heads were then cut open to measure core length and core diameter at the base. The number of leaves with tipburn disorder in each head was also noted.

The plant weight of the breeding lines was generally higher than other leaf lettuce cultivars (Table 2). The core length of the breeding lines was similar or shorter than the cultivars. A short core length is generally preferred by most lettuce processors. The tipburn leaves of the breeding lines were comparable to most commercial cultivars.

In the limited trials, the breeding lines performed well in the Salinas Valley, producing a high percentage of plants of adequate size, shape, and uniformity. The adaptation of these breeding lines to other lettuce-growing areas has not been evaluated.

Seed Availability

Limited samples of seed are available from the author for distribution to all interested parties for research purposes, including the develop-

ment and commercialization of new cultivars. Samples will also be deposited in the National Plant Germplasm System. It is requested that appropriate recognition be made if the breeding lines contribute to research or the development of new germplasm, breeding lines, or cultivars.

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