Crisphead Lettuce Resistant to Tipburn: Cultivar Tiber and Eight Breeding Lines

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Tipburn is a physiological disorder, one of many that may be related to calcium transport in various crop species (Shear, 1975). In lettuce (*Lactuca sativa* L.), tipburn is characterized by necrotic lesions at or near the margins of rapidly expanding leaves, probably when growth is accelerated by a late application of nitrogen or water or by a rise in temperature. Calcium is transported slowly through the plant and a shortage develops in the rapidly expanding leaf margins. This leads to cell membrane and wall breakdown, causing tissue necrosis (Collier and Tibbitts, 1982). The lesions are unsightly, and since they usually occur at or shortly before harvest, inspectors may impose a sanction against harvest. The result for the grower is loss of the crop, or at best, a discounted market price.

Lettuce cultivars vary considerably in tipburn reaction, ranging from development of large severe lesions to little or no lesion formation. Among current crisphead-type cultivars, 'Salinas' is considered the standard for resistance to tipburn development (Ryder, 1979a). This paper describes a new cultivar, 'Tiber', and eight related resistant breeding lines, with greater tipburn resistance than 'Salinas'.

Origin

Cultivar. 'Tiber' was released in 1995, jointly by U.S. Dept. of Agriculture (USDA)-Agricultural Research Service and the Univ. of California Agricultural Experiment Station. It was developed from the cross 'Vanguard 75' × 'Salinas'. 'Vanguard 75' has been a standard cultivar for the desert districts of California and Arizona for production in the late winter-early spring season since the late 1970s (Ryder, 1979b). 'Salinas' has been grown primarily in the California coastal districts. 'Salinas', and a large number of cultivars derived from it, comprise the principal

group of cultivars grown in the United States.

The original cross was made in 1976 and the F₁ was grown in the greenhouse the same year. An F₂ population (82-1809) was grown in 1982-83, in the warm San Joaquin Valley, near Huron, Calif., where selection for tipburn resistance can be effected. Ten F₃ families were grown in 1983-84 in Huron, and 10 tipburn-free selections were made in family 83-1400. F₄ progenies from these selections were planted in two replications in 1984-85 in Huron. Four of these families, 83-1400-1, -5, -6, and -10, were tipburn-free. These four families were planted again, in the Salinas Valley

at the USDA Spence Field location in 1987. Selections based on head type, color, and other horticultural traits were made in lines 87-714, 87-715, and 87-716, which were derived from 83-1400-5. This family showed the highest tipburn resistance in a trial in Aguila, Ariz. Subsequent selections were made in massed progenies from these F₅ families. 'Tiber' was increased from 87-714-2M (F₇ mass) (Fig. 1).

Breeding lines. These are also F₇ mass descendants of 83-1400-5 and include the following: 87-714-1M, 87-714-4M, 87-714-5M, 87-714-7M, 87-715-1M, 87-715-2M, 87-716-1M, and 87-716-2M. Their relationships to 'Tiber' and to each other are shown in Fig. 1.

Description

The following descriptions are based on trials in California (Salinas, Santa Maria, San Joaquin, and Imperial valleys) and Arizona (Yuma area and Aguila). Many of these were cooperative cultivar trials planted by V.E. Rubatzky, Univ. of California, Davis, and county farm advisors in California.

'Tiber' has dull, dark-green, outer leaves, similar to those of 'Salinas' and related cultivars. However, the leaves tend to be slightly more incised, indented, and undulate than those of 'Salinas'. Interior color is creamy yellow. The heads are firm to hard at maturity and are

Fig. 1. Pedigree of 'Tiber' and related breeding lines.

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usually large to very large (16.5 to 20 cm in diameter). In some cooler environments, the heads have been 1 to 5 cm smaller. The head is well rounded, with adequate cover, but little enclosure by the tops of the large green leaves. In this trait, 'Tiber' resembles 'Salinas' more than it does 'Vanguard 75.' The stem-end and leaf midribs are flat; the core is large. The stem is usually low to medium in height (3 to 6 cm). Leaf texture is relatively pliable, similar to 'Salinas'. Leaf surface is moderately crinkled or blistered. Seed color is black.

The breeding lines are similar in most traits to 'Tiber'. Lines 87-714-4M, 5M, and 7M, 87-715-1M and 2M, and 87-716-1M resemble 'Vanguard 75' to the extent that outer leaves cover the sides and top of the head.

Six tipburn trials in two Arizona locations, Maricopa and Aguila, during the period 1988–94, compared 'Tiber' and the breeding lines with susceptible cultivars (Table 1). All the trials matured in early May, when daytime temperatures ranged from 32 to 40 °C, which is strongly conducive to development of tipburn lesions. Additional trials were grown in Huron, Calif., in 1988–89; in the Salinas Valley in 1994, 1995, 1996, and 1997; in the Imperial Valley and Yuma in 1995–96 and 1996–97; and in Alaska (by S.M. Dofing, Univ. of Alaska) in 1991, 1995, and 1996. 'Tiber' was grown in all trials but one, and one or more of the breeding lines were grown in all trials. 'Tiber' and the breeding lines were not completely free of tipburn (Table 2). However, they showed either no tipburn lesions, or one or two small lesions in some plants, in nearly all trials. Tipburn incidence in the resistant materials was at least as low and usually lower than that in the other materials in the trials. In Alaska, the long-day environment is more conducive to tipburn development, and lesions were larger and appeared more frequently.

These materials have no resistance to lettuce mosaic virus or to current pathotypes of the downy mildew fungus (*Bremia lactucae* Regel), according to standard tests. Reaction to other diseases has not been documented.

Adaptation and performance

'Tiber' is adapted to all major growing areas in California and Arizona. In the limited trials grown, it has performed well in the Salinas Valley in all parts of the season, in early and midseason plantings in the desert districts, in some late trials in the desert, and in some spring trials in the San Joaquin Valley. Trials grown by V.E. Rubatzky (Univ. of California, Davis) cooperatively with county farm advisors in the Salinas, Santa Maria, San Joaquin, and Imperial valleys included 'Tiber' and cultivars submitted by seed companies. They were rated for earliness, uniformity, disease reaction, head conformation, size, and other traits. The ratings were made at or before harvest. An overall rating, based on expected harvest percentages, was assigned to each entry (Table 3). Ratings were made blindly, before identification of the entries in the trials. 'Tiber' ranked well in nearly all trials.

Table 1. Comparison of tipburn reactions of 'Tiber', eight breeding lines, and three lettuce cultivars in six trials in Central Arizona during the period 1988–94. Data show percentage of heads with tipburn, based on 10 or 15 heads per entry per trial.

Entry	Trial ^a					
	1	2	3 ^b	4	5 ^b	6
Tiber	0	10	0 a	0	0 a	0
87-714-1M	0	10	10 a	30	0 a	---
87-714-4M	0	10	20 a	10	0 a	20
87-714-5M	0	10	0 a	0	0 a	0
87-714-7M	0	10	---	---	---	---
87-715-1M	0	10	10 a	0	0 a	20
87-715-2M	0	0	---	---	---	10
87-716-1M	0	0	10 a	30	0 a	20
87-716-2M	0	10	---	---	0 a	---
Salinas	20	29	20 a	70	27 b	50
Vanguard 75	---	---	100 b	100	53 c	40
Calicel	---	---	100 b	100	100 d	100

^aTrial locations: 1, 4, 5, 6—Aguila; 2, 3—Maricopa.

^bTrials 3 and 5 were replicated. Mean separation by LSD, $P \leq 5\%$.

Table 2. Comparison of tipburn reactions of 'Tiber', seven breeding lines, and three lettuce cultivars in six trials in various locations during the period 1988–97. Percentage of heads with tipburn.

Entry	Trial ^a					
	1	2	3	4	5	6
Tiber	0	0	---	7.6	5.4	1.3
87-714-1M	0	0	0	---	---	---
87-714-4M	0	0	---	---	---	---
87-714-5M	0	0	0	10.0	11.4	5.1
87-714-7M	20	---	---	---	---	---
87-715-1M	0	0	---	---	---	---
87-715-2M	0	---	0	---	---	---
87-716-1M	0	0	---	22.8	40.3	6.3
Salinas	20	---	0	20.0	28.0	9.2
Target	---	0	---	---	---	---
Calicel	100	100	---	---	---	---

^aTrial locations: 1, 2—Salinas; 3—Huron; 4, 5, 6—Alaska.

Table 3. Rating and ranking of 'Tiber' compared with the average of other cultivars in coastal, San Joaquin Valley, and desert locations in California. Rating (1 = poorest, 9 = best) based on expected harvest percentage. Trials evaluated by V.E. Rubatzky, Univ. of California, Davis.

Location	Tiber		Mean cultivar rating	No. cultivars	Observation date ^a
	Rating	Rank			
Salinas	6.9	1	5.4	24	24 June 1997
Salinas	7.4	5	7.0	17	3 July 1996
Soledad	7.0	4	5.4	26	10 July 1995
Santa Maria	7.8	2	4.6	21	22 July 1996
Salinas	7.4	2	5.2	31	15 Aug. 1995
Salinas	6.3	2	5.2	27	16 Aug. 1996
Salinas	7.1	3	6.6	23	15 Oct. 1996
Huron	2.8	11	6.2	13	3 Nov. 1995
Holtville	2.8	12	3.3	17	2 Dec. 1996
Brawley	6.8	1	4.2	18	13 Dec. 1996
Holtville	6.3	3	5.0	21	7 Feb. 1997
Huron	5.9	7	5.0	21	4 Apr. 1997

^aArranged by harvest date across years.

'Tiber' is distinguished primarily by its tipburn resistance, but also by its relatively large size in many environments. These traits make it a viable candidate for use as a lightly processed product, both for institutional and consumer packages.

Tipburn reaction of the related breeding lines has also been evaluated in many trials (Tables 1 and 2). Their adaptation and performance in the field are less well documented.

Availability

'Tiber' was officially released in 1995. Release of the breeding lines is announced

with this paper. Seed of the cultivar should be available in commercial quantities from most seed companies. Small amounts of seed of the breeding lines are available from E.J.R.

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