

**Evaluation of
Bacterial Soft Rot-Tolerant
Crisphead Lettuce Cultivars in Hawaii**

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ABSTRACT

Previous field experiments at the Maui Research Center in Kula, Hawaii, were used as a basis for determining which cultivars of crisphead lettuce are resistant to bacterial soft rot incited by *Erwinia carotovora*. Several of these resistant cultivars were selected for field trials at Kula at 1400- and 2100-foot elevations for cooperative research between the University of Hawaii and Maui growers.

At the 1400-foot level, cultivars 'Ithaca', 'Fulton', 'Empire', and 'Minetto' were evaluated; at the 2100-foot level, cultivars 'Ithaca', 'Fulton', 'Empire', 'Salinas', 'King Crown', and 'Vanguard' were evaluated.

Incidence of loss due to disease was low at the 1400-foot level: loss from drop ranged from a low of 0 for 'Empire' to 0.5 percent for 'Fulton'; loss from bottom rot ranged from a low of 1 percent for 'Ithaca' to 4.2 percent for 'Minetto'; no losses occurred from bacterial soft rot. 'Ithaca' and 'Fulton' produced the highest estimated yield per acre.

More disease losses were observed at the 2100-foot level: the percentage of loss due to drop was significantly higher with 'King Crown' at 15.8 percent and 'Fulton' at 20.0 percent than with the other cultivars; 'Fulton' also appeared more susceptible to bottom rot (17.5 percent) than the other cultivars. All cultivars were low in losses due to bacterial soft rot. 'Ithaca' and 'Empire' performed best at the 2100-foot level.

Additional key words: *Lactuca sativa* L., *Sclerotinia sclerotiorum*, *Rhizoctonia solani*.

INTRODUCTION

Crisphead lettuce (*Lactuca sativa* L.) represents the largest vegetable crop grown in Hawaii and accounts for approximately 11 percent of Hawaii's annual income from all vegetable crops (4). A total of about 350 acres is devoted to lettuce production, which annually yields about 5.6 million pounds.

Several diseases place major constraints on the expansion of this industry. Of these diseases, bacterial soft rot, caused by *Erwinia carotovora*, accounts for the major share of the losses in lettuce (2). Although soft rot has been reported to occur in Florida and New York (1, 6, 8), it is not considered of major importance in comparison with other diseases. Soft rot is generally observed near or at maturity. Initial symptoms include a wilting of individual leaves or of several outer-wrapper leaves. Wilting is generally associated with collapsed vascular tissues, which are light brown to red when observed from the cut stem end. As the disease advances, the stem's pith becomes water-soaked and macerated. Wilting of the mature head is associated with extensive maceration of the pith area. This wilting and collapse of the plant is similar to lettuce drop symptoms.

Maui growers lost approximately 10 to 25 percent in production during the summer and fall of 1975; however, during the wet 1975 winter and early 1976 spring, soft rot losses resulted in yield reductions of up to 90 percent on several farms (2). Records (4) from the 5-year period 1971 to 1975 (Figure 1) indicate that reduction in lettuce production during the winter season is quite common, partly due to disease losses.

Several other diseases, in addition to soft rot, contribute to Hawaii's yield reduction. These include several fungal diseases caused by *Sclerotinia sclerotiorum* (drop) and *Rhizoctonia solani* (bottom rot); a bacterial leaf spot caused by *Xanthomonas vitians*; and three virus diseases caused by lettuce mosaic virus (LMV), beet western yellows virus (BWYV) (7), and spotted wilt virus.

The main objective in conducting the trials reported here was to evaluate soft rot-tolerant lettuce cultivars on a large scale in order to determine the best in terms of disease tolerance, adaptability, and market acceptance.

MATERIALS AND METHODS

Cultivars

The lettuce cultivars 'Ithaca', 'Fulton', 'Vanguard', 'King Crown', 'Salinas', and 'Empire' were germinated and transplanted at a location 2100 feet in elevation. At a 1400-foot elevation, the cultivars 'Ithaca', 'Fulton', 'Empire', and 'Minetto' were germinated and transplanted.

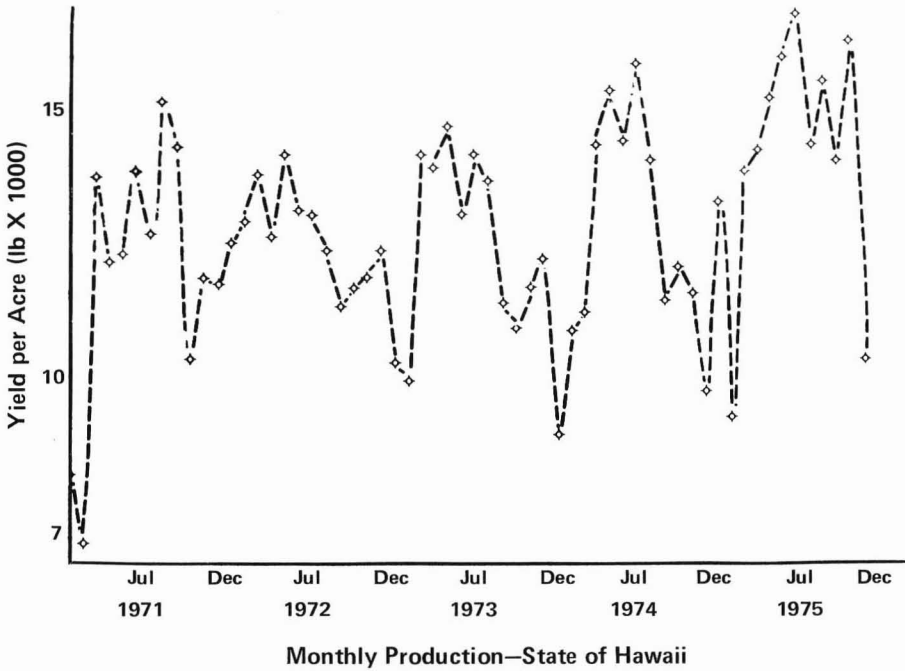


Fig. 1. Monthly production fluctuations, 1971 to 1975, in yield per acre of crisp-head lettuce in Hawaii. (Data transformed from reference 4.)

Cultural Practices

Standard grower practices of irrigation, fertilization, pesticide application, weed control, and cultivation were used, as previously described (2, 3, 7). Plants at the higher elevation were transplanted on December 10, 1976, and at the lower elevation on December 13, 1976, making two or four beds about 100 feet in length, with three replicates in a complete random block design.

Cultivar Evaluations

Numbers of marketable heads, average head weights, and numbers of diseased plants were evaluated at crop maturity. Average head weights were determined by combining and weighing five boxes containing 20 heads each from each replicate. Disease evaluations were based on visible symptoms.

RESULTS

Previous Trials at Pulehu

Several experiments aimed at developing procedures for controlling bacterial soft rot have been conducted at the Maui Research Center. Disease resistance is an effective control of losses from several serious plant diseases. In this respect, trials were conducted in 1975 and 1976 at the Pulehu field of the research center to determine the relative susceptibilities of 33 cultivars to soft rot, compared with the cultivars 'Calmar' and 'Mesa 659', which are presently grown on Maui. The cultivars 'Empire', 'Minetto', 'Fulton', 'Ithaca', 'Vanguard', 'Vanmax', and 'King Crown' were consistently found to be tolerant to soft rot. Table 1 summarizes these trials.

The losses attributed to bacterial soft rot were low for 'Ithaca' (15 percent), 'Empire' (12 percent), 'King Crown' (11 percent), 'Fulton' (13 percent), 'Vanmax' (14 percent), 'Minetto' (14 percent), and 'Vanguard' (15 percent). In contrast, soft rot losses were high for 'Calmar' at 63 percent and 'Mesa 659' at 56 percent. Head formation was erratic for 'Vanguard' and 'Vanmax', especially during the warmer months. 'Calmar', 'King Crown', 'Vanguard', and 'Vanmax' formed large heads weighing over 2 pounds, compared with the small- to medium-sized, compact heads

Table 1. Comparison of several attributes of bacterial soft rot-tolerant crisphead lettuce cultivars with 'Calmar' and 'Mesa 659' (summary of several trials)

Cultivar	Average loss due to soft rot (%)	Attributes			Estimated yield (lb/acre)	
		Average head weight (lb)	Planting space interval (inches)	Number of days to maturity	Actual	Potential
Ithaca	15	1.9	12	43	42,100	49,529
Ithaca	15	1.9	14	43	36,179	42,564
Empire	12	2.0	14	48	39,427	44,804
Empire	12	2.0	16	48	34,059	38,704
Calmar	63	2.3	18	52	14,828	40,075
Calmar	63	2.3	20	52	13,345	36,069
Mesa 659	56	1.7	18	52	13,033	29,621
Mesa 659	56	1.7	20	52	11,730	26,659
Vanguard	15	2.2	18	55	32,583	38,333
Vanmax	14	2.4	18	55	35,963	41,818
Minetto	14	1.8	12	40	40,353	46,422
King Crown	11	2.2	18	55	34,116	38,333
Fulton	13	2.1	14	43	40,928	47,044

of 'Ithaca', 'Empire', 'Minetto', and 'Fulton'. On the other hand, estimated yield potentials of the latter cultivars were equal to or better than those of the former, since the latter cultivars could be planted at closer space intervals and were more soft rot tolerant.

Seedlings of these tolerant cultivars were distributed to growers for transplanting on farms located at elevations ranging from 1400 to 3200 feet. Those cultivars that performed well with regard to disease tolerance and cultural characteristics were selected for the trials reported below.

Trial at Lower (1400-Foot) Elevation

The results of this trial are summarized in Table 2. 'Minetto', 'Fulton', and 'Ithaca' formed small compact heads with short cores. 'Minetto' matured about 3 days earlier than the other two but was smaller, with a lower average head weight (1.61 pounds vs 1.88 for 'Fulton' and 1.93 for 'Ithaca'). Although not evident from the standpoint of marketable heads, *Rhizoctonia solani* (bottom rot) infections were more severe on 'Fulton' than on the rest; however, these infections were confined to the lower wrapper leaves and therefore were not recorded as disease losses. Infections may be more severe under more unfavorable conditions of higher moisture and warmer temperatures and result in higher losses to 'Fulton'. 'Empire' was lower in average head weight compared to previous trials (Table 1) due to its loose head formation. 'Ithaca' was a darker green than the others, and was by far the best cultivar during this trial. It had an average head weight of 1.93 pounds (18 to 19 heads per carton) and yielded an estimated 38,307 pounds per acre.

Trial at Higher (2100-Foot) Elevation

The results of this trial are summarized in Table 3. Several cultivars did not do well in this test. 'Vanguard' and 'King Crown', for example, developed more slowly and had a higher percentage of loss due to a large number of loose heads. 'Salinas' and 'Fulton' were more susceptible to two fungal diseases—*Sclerotinia sclerotiorum* (drop) and *Rhizoctonia solani* (bottom rot)—than the other cultivars. On the other hand, a high percentage of 'Ithaca' and 'Empire' heads was marketable. 'Ithaca' formed early-maturing, compact heads that weighed about 2 pounds (17 to 18 heads per carton) and yielded an estimated 39,063 pounds per acre. 'Empire' matured about 3 to 5 days after 'Ithaca', had an average head weight of about 2 pounds (17 to 18 heads per carton), and yielded an estimated 28,893 pounds per acre when planted at 18-inch intervals. This cultivar formed slightly pointed heads.

Table 2. Comparison of bacterial soft rot-tolerant crisphead lettuce cultivars grown at 1400-foot elevation

Cultivar	Marketable ^x (%)	Average head weight (lb) ^x	Planting space interval (inches)	Percent loss ^x due to:				Estimated yield (lb/acre)
				Drop	Bottom rot	Soft rot	No head	
Ithaca	88.6 b ^y	1.93 b	14	0.3 a	1.0 a	0.0 a	8.2 a	38,307 b
Fulton	89.7 b	1.88 b	14	0.5 a	2.0 a	0.0 a	7.0 b	37,778 b
Empire	74.1 a	1.67 a	18	0.0 a	3.3 a	0.0 a	19.2 c	21,562 a
Minetto	94.8 b	1.61 a	14	0.4 a	4.2 a	0.0 a	0.6 a	34,192 b

^xAverage of 3 replicates that comprised a total of 250 plants each.

^yNumbers followed by the same letter are not significantly different ($P = 0.05$) according to Duncan's Multiple Range Test.

Table 3. Comparison of bacterial soft rot-tolerant crisphead lettuce cultivars grown at 2100-foot elevation

Cultivar	Marketable ^x (%)	Average head weight (lb) ^x	Planting space interval (inches)	Percent loss ^x due to:			Estimated yield (lb/acre)
				Drop	Bottom rot	Soft rot	
Ithaca	85.9 d ^y	2.03 b	14	7.6 a	2.2 a	0.0 a	39,063
Fulton	59.2 c	1.83 b	14	20.0 ab	17.5 b	0.0 a	24,269
Empire	82.5 d	2.01 b	18	4.1 a	5.2 a	0.0 a	28,893
Salinas	35.0 b	2.02 b	14	38.3 b	5.0 a	0.4 a	15,838
King Crown	61.7 c	1.95 b	18	15.8 a	0.0 a	0.0 a	20,964
Vanguard	21.0 a	1.51 a	18	5.8 a	0.8 a	4.2 a	5,525

^xAverage of 3 replicates that comprised a total of 250 plants each.

^yNumbers followed by the same letter are not significantly different ($P = 0.05$) according to Duncan's Multiple Range Test.

DISCUSSION

During the past 5 years, Hawaii imported between 9.3 and 10.4 million pounds of lettuce annually (4)—about twice the amount produced. Moreover, the ability of Hawaii's growers to substantially increase present yields is severely limited. Losses attributable to biological diseases appear to be a bottleneck in attaining maximum production and perhaps self-sufficiency for the State. Before any major production increases can be achieved, procedures for disease control must be developed. Once diseases are reduced, expanded processing and handling facilities should certainly be developed to handle the increased production.

The crisphead lettuce cultivars 'Ithaca', 'Empire', and 'Fulton' appear very promising and should be tried as possible replacements for cultivars presently grown. These cultivars should be planted during the cooler months (November through early March). 'Ithaca' does well at elevations of 1400 to 2100 feet; 'Empire' at elevations of 2100 feet, and 'Fulton' at 1400 feet. Although 'King Crown' did poorly in this trial, it has performed well in previous trials and should be tried at elevations ranging from 2100 to 2800 feet. 'Salinas' performed well not only in previous trials, where *Sclerotinia sclerotiorum* losses were reduced with applications of Botran and maneb fungicides, but also during summer and fall months, as it appears to be tolerant to *Rhizoctonia solani* infections. 'Salinas' should be tried at 1800- to 2800-foot elevations as a possible replacement for 'Mesa 659'; however, until more information is obtained, 'Mesa 659' should continue to be planted during the warm, dry periods of the year.

On Maui, it is conservatively estimated that in 1976 a 400,000-pound loss due to soft rot could have been averted if current cultivars had been replaced by one of these cultivars. Since 'Ithaca' and 'Empire' mature earlier than 'Calmar' and 'Mesa 659', they can be transplanted at closer intervals (12 to 14 inches for 'Ithaca' and 14 to 16 inches for 'Empire'). This characteristic alone will increase yield by approximately 10 percent.

Replacement of the current lettuce cultivars with soft rot-tolerant ones makes Hawaii's self-sufficiency in crisphead lettuce production possible within a relatively short time. However, in previous tests (unpublished), 'Ithaca' and 'Empire' appeared more susceptible to bottom rot. Several fungicides shown to reduce losses due to bottom rot (3, 5) are available, and these should be used in conjunction with these cultivars for increasing production.

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