The Connecticut Agricultural Experiment Station, New Haven

Crisphead Lettuce (Iceberg) Trials 1991-1992

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SUMMARY

During 1991-1992, cultivar trials of crisphead lettuce were conducted during the spring and fall at Mt. Carmel (coastal, loamy upland soil) and Windsor (inland, sandy terrace soil). In spring 1991, average yield of eight cultivars harvested at both sites was 20,490 lb/A in the first crop and 14,960 lb/A in the second crop. Lower yields in the second crop were attributed to below average rainfall. Head weight was reduced from 1.1 lb in the first crop to 0.7 lb in the second crop. Highest yield and quality were from Frosty, Gemini, and Great Lakes 659. In fall 1991, average yield of eight cultivars at both sites was 11,550 lb/A in the first crop, 12,520 lb/A in the second crop, and 8,060 lb/A in the third crop. In the first crop, excessive bolting and bottom rot was noted in Crispino and Gemini at both sites. In the third crop, low yields were due to small heads and increasing numbers of non-heading plants as daylength and temperature decreased. Frosty consistently had the highest yield and quality in all three crops.

In spring 1992, average yield of 13 cultivars at both sites was 16,930 lb/A in the first crop and 22,270 lb/A in the second crop. In the first crop, 25% of the heads were lost to bottom rot; none in the second crop. Yields of Duchesse, Frosty, Gemini, Great Lakes 659, and Mesa 659 exceeded 21,000 lb/A and were of excellent quality. In fall 1992, average yield of 13 cultivars was 18,310 lb/A in the first crop. Cool weather produced larger heads in fall 1992 than in fall 1991, but 46% of all plants failed to form heads. Yields of Gemini and Summertime exceeded 22,400 lb/A at both sites, and quality was excellent.

Maturity of an entire crop was controlled mostly by daylength and weather, but minor differences in maturity among individual cultivars were due to genetic predisposition.

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Lettuce ranks second among all vegetables produced for consumption in the United States, exceeded only by potatoes. According to USDA statistics, 5.5 billion pounds are produced annually, and California and Arizona are the major suppliers (Anon 1991). Lettuce is available year-round because winter production occurs in frost-free areas of the United States and is supplemented with imports from Mexico. Summer crops are supplemented with local production in Michigan, Wisconsin, New York, and New Jersey (Ryder 1979).

Lettuce (*Lactuca sativa L.*) may be divided into five types: crisphead, butterhead, cos or romaine, leaf, and stalk. Crisphead is by far the most popular because it can be shipped with little loss of quality. For this reason, I concentrated my trials on crisphead types.

Production in Connecticut

Traditionally lettuce has been produced in Connecticut for local consumption during summer months. In the early 1900's centers of production were located in Windsor along the floodplain of the Connecticut River and in vegetable producing areas of Cheshire, North Haven, and Wallingford. Most of these areas are no longer in production due to urban expansion. In 1982, 100 acres of lettuce were reported in Connecticut (Stephens et al. 1988). Most of the lettuce grown is of the romaine, leaf, and crisphead types. Butterhead lettuce has been grown hydroponically in Lakeville and Hartford. Most lettuce in Connecticut is grown for direct marketing through roadside stands.

Current Outlook

The recent rapid growth of the food service industry, which encompasses fast-food chains, restaurants, school and corporate cafeterias, and hospitals, has created a large demand, especially for crisphead lettuce. The food service industry uses about one-third of all lettuce produced in the United States, and crisphead lettuce accounts for 70% of all lettuce served (Anon 1990). Further, increased demand in the past decade is due to increasing numbers of people who include salads in their daily diet.

In the past few years drought, freezing temperatures, infestation of sweet potato white flies, and rising costs of transportation from California have given eastern growers an opportunity for profit. Lettuce prices, however, are highly volatile and reflect the supplies that are available at the time. Production for local direct marketing sales seems the most feasible because roadside prices are independent of California wholesale prices at the time of harvest.

In 1991, eight cultivars of crisphead lettuce were grown from transplants at the Valley Laboratory in Windsor and Lockwood Farm in Mt. Carmel. In 1992, the trials were expanded to 13 cultivars. I report yields, quality, and maturity of these cultivars in this bulletin. I shall also discuss strategies to maximize yields through cultivar selection, planting dates, and site selection.

METHODS AND MATERIALS

Soils

Lettuce trials were conducted at the Valley Laboratory, Windsor on Merrimac sandy loam, a sandy terrace soil with somewhat limited moisture holding capacity, and at Lockwood Farm, Mt. Carmel, on Cheshire fine sandy loam, a well drained loamy upland soil with modest moisture holding capacity.

Cultivars

Seeds were obtained from several domestic suppliers. A total of 15 cultivars of crisphead lettuce were grown throughout the 2-year trial. They are as follows:

	1991	1992
Cerise		X
Crispino	X	X
Duchesse		X
Frosty	X	X
Gemini	X	X
Great Lakes 659	X	X
Green Lake	X	X
Ithaca	X	X
Mesa 659		X
Minilake	X	
Mission		X
Montello		X
Premier Great Lake	X	
Salad Crisp	X	X
Summertime		X

Table 1. Soil and crop management of crisphead lettuce.

Activity	Spring Crops	Fall Crops
SOIL FERTILIZATION		
10-10-10	1200lb/A	1200lb/A
Calcium nitrate	190lb/A	190lb/A
(Side dress 1 month after transplanting)		
Lime (to attain pH 6.5)	None	None
PLANTING DATES		
Seeding in greenhouse or cold frame	Crop 1 March 4	June 18-24
	Crop 2 March 18	July 10-14
	Crop 3 -	July 27-28
Transfer to cold frame	Crop 1 April 5	-
	Crop 2 April 19	-
Transplanted to field	Crop 1 April 26-29	July 24-Aug 4
	Crop 2 May 8-14	Aug 12-16
	Crop 3 -	Sept 3-12
PEST CONTROL	None needed	None needed
NUMBER OF IRRIGATIONS		
Windsor	0	1
Mt. Carmel	0	1
WEED CONTROL		
Cultivations	2	2

Culture

Seeds for the first and second spring plantings were sown 2 weeks apart in a greenhouse maintained at 50-70F. Four-week-old seedlings were moved to a cold frame for hardening 3 weeks prior to field planting. The seedlings were transplanted at a 12-inch spacing in rows 24 inches apart to provide 21,780 plants/A. Each planting consisted of five random blocks with six plants per cultivar in each replication.

Seeds for the fall plantings were sown at 2-week intervals in a cold frame for germination. Five-to-six week old seedlings were transplanted to the field when they were 3-4 inches tall. In 1991, planting of seedlings for the third fall crop was delayed 1 week. In 1992, field planting of the second and third crops was delayed 2 and 3 weeks because of slow seedling growth.

The seedlings were grown in Promix BX in 36-pot packs, each pot 2-5/8 x 2-1/4 x 2-5/16 inches. Water soluble 20-10-20 fertilizer (1 tbsp/gal) was added to the seedlings 1 week before transplanting. Side dressing the crop with nitrogen, supplied as calcium nitrate, is important because the lettuce plant makes about 80% of its growth during the last 3 or 4 weeks before harvest (Zink and Yamaguchi 1962). The marketable heads of all cultivars were harvested at maturity. The heads were weighed and the quality judged for compactness of the head. The classes of compactness are as follows:

Loose: trimmed heads yield substantially to pressure when squeezed with finger tips. Outer leaves of trimmed heads overlap slightly at top.

Firm: trimmed heads yield slightly to pressure. Outer leaves overlap substantially.

Compact: trimmed heads resist pressure. Outer leaves overlap the entire head.

The details of management of soil and crops and pertinent dates are listed in Table 1.

Rainfall

Rainfall distribution throughout the growing season (1991-1992) is shown in Figure 1. Each bar represents the departure from the mean monthly rainfall reported by the National Weather Service for the weather station at Mt. Carmel. Total rainfall during the growing season (April-October) was 30.2 inches in 1991 and 29.7 inches in 1992 compared to the mean of 23.8 inches. In 1991 and 1992, below-average rainfall during April resulted in

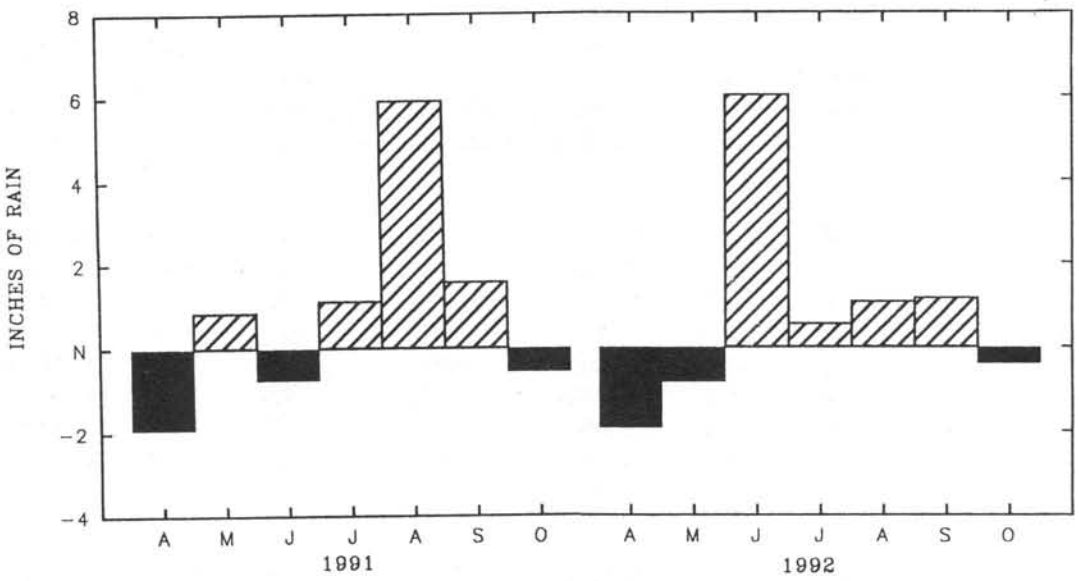

Figure 1. Departure of monthly rainfall (inches) from normal (N) during April-October, 1991-1992.

inadequate reserves for newly planted seedlings. In 1992 moisture deficits persisted through May. Moisture reserves were adequate July-September in 1991 and June-September in 1992. Excessive rainfall in August 1991 (Hurricane Bob) and June 1992 caused some rotting of maturing heads.

YIELD AND QUALITY

Spring Crops 1991

In Crop 1, transplanted April 26-29, the average yield of eight cultivars was 8% greater at Windsor (21,240 lb/A) than at Mt. Carmel (19,740 lb/A), a significant difference (Table 2). At Windsor, the higher average yield was due to slightly heavier heads (1.0 lb compared to 0.9 lb at Mt. Carmel). At both sites, 93 to 100% of each cultivar was marketable. At Windsor, the highest yield and quality were provided by Frosty and Gemini and at Mt. Carmel, Frosty and Great Lakes 659. The well-formed, compact heads of these cultivars had excellent quality. Minilake, a small-headed cultivar, also produced compact, well-formed heads.

In Crop 2, transplanted May 8-9, the average yield of nine cultivars was 81% greater at Windsor (19,300 lb/A) than at Mt. Carmel (10,630 lb/A), a significant difference. At Windsor, the greater average yield was due to larger heads (1.0 lb compared to 0.5 lb at Mt. Carmel). Weather records in June show that average rainfall at both sites during head formation was about 1 inch below normal, but heavy thunderstorms mid-month at Windsor, but not Mt. Carmel, prevented stunting of the crop. Despite the smaller heads at Mt. Carmel, fully 95% were marketable. At Windsor, the highest yield and quality were provided by Frosty and Crispino. At Mt. Carmel, Frosty had the highest yield despite smaller head weight. The yield of Salad Crisp was low because 17% of the plants failed to form heads at both sites.

Spring Crops 1992

In Crop 1, transplanted April 28-29, the average yield of 13 cultivars was 30% less at Windsor (13,990 lb/A) than at Mt. Carmel (19,870 lb/A), a significant difference (Table 3). The yields at Mt. Carmel were higher largely because an average of 20% more heads of each cultivar were marketable than at Windsor. At Windsor, heavy rains in early June caused 35% of the entire crop to rot compared to 15% at Mt. Carmel. Average head weight at Windsor and Mt. Carmel was 1.0 to 1.1 lb. Despite excessive crop loss at Windsor, the yield of Frosty was greatest with all heads of marketable quality. Yield of Great Lakes 659 and Mission was above average. Although Great Lakes 659 produced the heaviest heads, they were loose to firm and of poor quality. Mission, a medium-sized cultivar lost only 3% to rotting. At Mt. Carmel, 8 of 13 cultivars produced compact heads of excellent quality. Yields of Duchess, Frosty, Gemini, Great Lakes 659, Green Lake, Mesa 659 and Mission were highest with 97 to 100% marketable heads. Losses due to bottom rot exceeded 30% in Ithaca, Montello, and Salad Crisp.

In Crop 2, transplanted May 13-14, the average yield of 13 cultivars at Windsor and Mt. Carmel was virtually the same (22,160 lbs/A vs 22,380 lb/A) (Table 3). The average head weight at Windsor was slightly heavier than at Mt. Carmel, but average losses due to rotting were 8% greater at Windsor than at Mt. Carmel. At both sites, losses from

Table 2. Yield of crisphead lettuce at Windsor and Mt. Carmel, Spring 1991.

	WINDSOR				MT. CARMEL			
Cultivar	Heads hvst. %	Avg. wt. oz	Total yield[x] lb/A[y]	Crates/A[z]	Heads hvst. %	Avg. wt. oz	Total yield[x] lb/A[y]	Crates/A[z]
CROP 1								
Crispino	100	15.5	21,140b	705	100	15.6	21,190abc	705
Frosty	100	18.3	24,910a	830	100	19.7	26,770a	890
Gemini	100	17.0	23,190ab	775	100	15.5	21,145abc	705
Great Lakes 659	100	15.6	21,240ab	710	100	16.4	22,280ab	740
Green Lake	100	15.2	20,740bc	690	100	11.9	16,200cd	540
Ithaca	97	15.2	20,080bc	670	97	14.4	19,080bcd	635
Minilake	93	13.4	16,960c	565	97	10.5	13,840d	460
Salad Crisp	100	15.9	21,690ab	725	97	13.2	17,390bcd	580
CROP 2								
Crispino	100	17.3	23,600ab	785	90	8.9	10,890bc	365
Frosty	93	20.2	25,540a	850	100	9.1	15,250a	510
Gemini	97	14.8	19,530abc	650	100	9.3	12,390ab	415
Great Lakes 659	97	15.8	20,810ab	695	100	6.6	12,610ab	420
Green Lake	80	12.2	13,340c	445	93	7.8	8,410c	280
Ithaca	83	15.2	17,170bc	570	97	11.2	10,240bc	340
Minilake	100	12.2	16,610bc	555	97	6.1	8,010c	265
Premier Great Lake	97	15.3	20,260abc	675	97	7.8	10,290bc	345
Salad Crisp	83	14.9	16,810bc	560	83	6.7	7,590c	255

x Based on 1'x 2' spacing or 21,780 plants/A.

y Mean separation within columns by Tukey's HSD multiple comparison test at P = 0.05. Values in columns followed by the same letter within each crop did not differ significantly.

z Based on standard 30-lb crate.

bottom rot in Crop 2 were less than Crop 1. At Windsor, average weight of heads of 10 of 13 cultivars exceeded 1.0 lb, at Mt. Carmel, 12 of 13 cultivars. Yields of Crispino, Duchesse, and Frosty were highest among all cultivars at Windsor and Mt. Carmel. Great Lakes 659 had the heaviest heads at both sites but the heads were mostly loose and losses due to bottom rot were 37% at Windsor and 53% at Mt. Carmel. Although heads of Gemini and Summertime were slightly smaller at both sites, they were of excellent quality with 93-100% marketable heads.

Fall Crops 1991

In Crop 1, transplanted July 24-26, the average yield of eight cultivars was 12% less at Windsor (10,820 lb/A) than at Mt. Carmel (12,280 lb/A) (Table 4). The difference was not significant. The relatively poor yields at both sites, compared to 1991 yields in spring were due to excessive bolting, bottom rot, and failure to form heads. Bolting was greatest in cultivars Crispino and Gemini with 47% and 63%, respectively, at Windsor; and 23% and 27% at Mt. Carmel. Bottom rot at both sites was greatest in Frosty (38%), Great Lakes 659 (35%) and Crispino (18%). At Windsor, only 46% of the entire crop had marketable heads; 65% at Mt. Carmel. At Windsor, Premier Great Lake had the greatest yield with 67% harvested. Minilake, a small headed cultivar, had 70% marketable heads. At Mt. Carmel, Frosty had the greatest yield, but the large heads were loose to firm and 43% of the plants were unmarketable. Crispino and Great Lakes 659 also had above-average yields even though 43% of both cultivars was unmarketable.

In Crop 2, transplanted August 12-16, the average yield of eight cultivars was 26% greater at Windsor (13,950 lb/A) than at Mt. Carmel (11,100 lb/A), a significant difference. Despite smaller heads, an average of 80-84% of all cultivars at both sites was marketable. At both sites, Frosty produced the greatest yield with compact heads of excellent quality on 87%-90% of the plants. At Windsor, yield of Crispino was also high with excellent marketable quality on 90% of the

Table 3. Yield of crisphead lettuce at Windsor and Mt. Carmel, Spring 1992.

	WINDSOR				MT. CARMEL			
Cultivar	Heads hvst. %	Avg. wt. oz	Total yield[x] lb/A[y]	Crates/A[z]	Heads hvst. %	Avg. wt. oz	Total yield[x] lb/A[y]	Crates/A[z]
CROP 1								
Cerise	40	17.4	9,480bc	315	80	14.5	15,790cde	525
Crispino	47	14.9	9,550bc	320	67	14.9	13,640de	455
Duchesse	97	13.0	17,120abc	570	100	16.8	22,910abcd	765
Frosty	100	19.4	26,360a	880	93	21.9	27,720a	925
Gemini	80	14.0	15,250abc	510	97	10.2	21,350abcde	710
Great Lakes 659	60	22.4	18,330ab	610	73	23.0	22,900abcd	765
Green Lake	60	13.9	12,980bc	430	97	17.1	22,580abcd	750
Ithaca	70	16.0	15,200abc	505	70	17.2	16,380bcde	545
Mesa 659	83	15.9	17,940ab	600	97	19.9	26,270ab	875
Mission	97	14.4	18,990ab	635	97	16.5	21,760abcde	725
Montello	23	13.6	4,250c	140	63	14.2	12,190e	405
Salad Crisp	13	13.2	4,010c	135	70	15.6	14,880cde	495
Summertime	77	13.4	14,080bc	470	97	15.1	19,940abcde	665
CROP 2								
Cerise	60	24.0	19,560cd	650	63	16.4	14,040c	470
Crispino	100	22.8	31,080a	1035	97	20.3	26,820ab	895
Duchesse	100	23.3	31,720a	1055	100	19.7	26,820ab	895
Frosty	100	22.2	30,170ab	1005	100	20.4	27,770a	925
Gemini	93	15.0	18,940abc	630	100	16.0	21,780bc	725
Great Lakes 659	63	25.2	21,620bcd	720	47	21.7	18,050bc	600
Green Lake	93	13.3	16,860cd	560	97	16.1	21,310bc	710
Ithaca	97	17.8	23,490abc	785	97	15.6	20,630bc	690
Mesa 659	87	16.4	19,400cd	645	97	19.8	26,180ab	870
Mission	70	17.2	16,430cd	550	97	19.0	25,130ab	840
Montello	63	14.8	12,730d	425	100	16.0	21,820bc	725
Salad Crisp	90	17.8	21,870abc	730	100	16.1	21,870bc	730
Summertime	93	19.2	24,280abc	810	100	16.9	22,900b	765

x Based on 1'x 2' spacing or 21,780 plants/A.

y Mean seaparation within columns by Tukey's HSD multiple comparison test at P = 0.05. Values in columns followed by the same letter within each crop did not differ significantly.

z Based on standard 30-lb crate.

plants. At Mt. Carmel, most cultivars in this crop produced small marketable heads.

In Crop 3, transplanted September 3-4, the average yield of eight cultivars was 117% greater at Windsor (11,030 lb/A) than at Mt. Carmel (5,080 lb/A), a significant difference. The smaller yield of Crop 3 compared to Crop 2 at both sites was due to a reduction in head weight and marketable heads. At Mt. Carmel, 32% of the plants were non-heading. At Windsor, Frosty, Crispino, Gemini, and Salad Crisp produced the greatest yields of small, compact heads. At Mt. Carmel, all cultivars produced very small heads of poor quality.

Fall Crops 1992

In Crop 1, transplanted August 4-6, the average yield of 13 cultivars was 33% greater at Windsor (20,940 lb/A) than at Mt. Carmel (15,680 lb/A), a significant difference (Table 5). Compared to fall Crop 1 in 1991, average yields in 1992 were 93% greater at Windsor and 28% greater at Mt. Carmel, both significant differences. The cool, wet weather

Table 4. Yield of crisphead lettuce at Windsor and Mt. Carmel, Fall 1991.

	WINDSOR				MT. CARMEL			
Cultivar	Heads hvst. %	Avg. wt. oz	Total yield[x] lb/A[y]	Crates/A[z]	Heads hvst. %	Avg. wt. oz	Total yield[x] lb/A[y]	Crates/A[z]
CROP 1								
Crispino	30	12.1	4,950c	165	57	16.2	12,550ab	420
Frosty	40	24.7	13,430abc	450	57	24.4	18,940a	630
Gemini	20	15.3	4,170c	140	63	14.9	12,770ab	425
Great Lakes 659	43	26.5	15,490ab	515	57	16.2	12,550ab	420
Ithaca	57	18.1	13,770abc	460	73	11.8	11,430ab	380
Minilake	70	10.0	9,530bc	320	83	9.6	10,080b	335
Premier Great Lakes	67	18.0	16,370ab	545	80	11.3	12,340ab	410
Salad Crisp	40	16.2	8,850bc	295	53	10.5	7,580b	250
CROP 2								
Crispino	90	15.0	18,420ab	615	87	9.5	11,250b	375
Frosty	87	16.8	19,860a	660	90	16.0	19,560a	650
Gemini	90	11.8	14,520abc	485	87	7.1	8,430b	280
Great Lakes 659	67	11.7	10,720cd	355	77	11.1	11,620ab	385
Ithaca	90	12.0	14,700abc	490	87	8.9	10,520b	350
Minilake	80	10.8	11,710bcd	390	80	8.0	8,760b	290
Premier Great Lakes	93	12.8	16,140abc	540	83	8.4	9,490b	315
Salad Crisp	40	10.2	5,540d	185	80	8.4	9,170b	305
CROP 3								
Crispino	97	11.5	15,210a	505	83	6.6	7,460a	250
Frosty	83	12.6	14,190ab	475	87	6.6	7,880a	260
Gemini	97	9.3	12,250ab	410	73	4.1	4,110ab	135
Great Lakes 659	23	12.3	3,850b	130	60	5.8	4,760ab	160
Ithaca	80	8.7	9,440ab	315	47	4.5	2,880b	95
Minilake	77	8.3	8,660ab	290	67	5.6	5,150ab	170
Premier Great Lakes	87	10.3	12,210ab	405	73	5.8	5,740ab	190
Salad Crisp	93	9.8	12,480ab	415	53	3.7	2,700b	90

x Based on 1'x 2' spacing or 21,780 plants/A.

y Mean separation within columns by Tukey's HSD multiple comparison test at P = 0.05. Values in columns followed by the same letter within each crop did not differ significantly.

z Based on standard 30-lb crate.

in August and September produced larger plants, but 41% at Windsor and 51% at Mt. Carmel were non-heading. Those that formed heads averaged 1.5 lb at Windsor and 1.4 lb at Mt. Carmel. At Windsor, Gemini and Summertime produced large, compact heads with good marketable quality on 90% of the plants. The compactness of heads of other cultivars ranged from loose to firm. At Mt. Carmel, these cultivars also produced large, compact heads of good quality on 75% of the plants. Crispino and Green Lake produced large, firm heads at both sites, but they were less compact than Gemini and Summertime.

Crops 2 and 3, seeded in containers July 14 and July 28, grew very slowly because of the cool, wet weather in August. Four-inch seedlings, planted in the field September 12-22, failed to produce marketable heads as daylength and temperature decreased.

Table 5. Yield of crisphead lettuce at Windsor and Mt. Carmel, Fall 1992.

	WINDSOR				MT. CARMEL			
	Heads hvst.	Avg. wt.	Total yield[x]		Heads hvst.	Avg. wt.	Total yield[x]	
Cultivar	%	oz	lb/A[y]	Crates/A[z]	%	oz	lb/A[y]	Crates/A[z]
Cerise	20	17.8	4,860c	160	7	17.0	1,620a	55
Crispino	70	26.8	25,590ab	855	67	26.0	23,710a	790
Duchesse	73	30.1	29,950ab	1000	53	23.9	17,270a	575
Frosty	67	31.4	28,640ab	955	50	27.0	18,380a	615
Gemini	90	28.9	35,390a	1180	77	24.6	25,790a	860
Great Lakes 659	27	21.1	7,760c	260	33	20.2	9,070a	300
Green Lake	73	20.6	20,510abc	685	73	18.1	17,980a	600
Ithaca	43	24.6	14,410bc	480	43	26.4	15,480a	515
Mesa 659	70	33.6	31,990a	1065	53	27.9	20,160a	670
Mission	53	23.9	17,270bc	575	30	19.4	7,940a	265
Montello	70	23.0	21,920abc	730	53	18.7	13,480a	450
Salad Crisp	17	13.3	3,090c	105	30	25.8	10,530a	350
Summertime	90	25.2	30,900a	1030	73	22.5	22,400a	745

x Based on 1'x 2' spacing or 21,780 plants/A.

y Mean separation within columns by Tukey's HSD multiple comparison test at P= 0.05. Values in columns followed by the same letter did not differ significantly.

z Based on standard 30-lb crate.

Table 6. Average days to maturity among all cultivars of head lettuce at Windsor and Mt. Carmel 1991-1992.

	1991			1992		
Seeding Date	Seed to transplant	Transplant to harvest	Total*	Seed to transplant	Transplant to harvest	Total*
April 26-29	54	38	92	56	47	103
May 8-9	52	34	86	56	41	97
July 24-26	31	40	71	48	50	98
August 12-16	35	55	90	-	-	-
September 3-4	38	60	98	-	-	-

* The total days to maturity were calculated from the seeding date to the date when half of the heads were harvested.

MATURITY

Maturity of head lettuce is important in scheduling planting for a specific harvest. The days to maturity, reported in seed catalogues, is generally calculated from the seeding date to harvest. The numbers reported are an average over many site conditions and acquired genetic characteristics. Since all of my crops were transplanted seedlings rather than direct seeded in the field, I divided maturity into two elements, days from seeding to 4-inch transplant, and days from transplant to harvest. The days to maturity from transplanting to harvesting is dependent upon daylength and weather as noted in broccoli and cauliflower (Hill 1989) and Chinese cabbage and Pak choi (Hill 1990). As daylength and temperature increases, maturity shortens about 3 weeks in June and July and then increases again as daylength and temperatures decrease (Table 6). This is consistent with the pattern of head lettuce maturity reported in the Salinas Valley, CA (Ryder 1979). The same trend is also noted in the production of seedlings for transplanting. Seven weeks were required to produce 4-inch transplants in the greenhouse in April and May and only 4 or 5 weeks to produce similar transplants in July and August. The span of time required to produce a harvestable head from transplants was shortest in

Table 7. Number of crops with one-day harvests and harvest span of crisphead lettuce cultivars grown spring and fall at Windsor and Mt. Carmel, 1991-1992.

	Spring			Fall		
	Crops grown No.	Crops w/ 1-day hvsts No.	Avg. hvst span* Days	Crops grown No.	Crops w/ 1-day hvsts No.	Avg. hvst span* Days
Cerise	4	0	6	2	2	1
Crispino	8	4	3	8	1	11
Duchesse	4	1	4	2	0	10
Frosty	8	1	6	8	3	7
Gemini	8	1	4	8	3	7
Great Lakes 659	8	3	3	8	3	6
Green Lake	8	5	2	2	1	6
Ithaca	8	5	2	8	3	8
Mesa 659	4	0	5	2	1	6
Minilake	4	4	1	6	3	6
Mission	4	4	1	2	2	1
Montello	4	2	4	2	2	1
Premier Great Lake	3	2	2	6	1	8
Salad Crisp	8	2	4	8	5	6
Summertime	4	0	6	2	0	10

*Time from first picking until 90% of crop was harvested.

crops planted in May (5 weeks) and longest in crops planted in early September (8.5 weeks).

In 1991, higher-than-normal temperatures speeded maturity in spring 10 days, compared to 1992 when temperatures were normal. The development of 4-inch seedlings for spring transplanting, however, was similar in 1991 and 1992 because they were grown under similar conditions in a heated greenhouse. Once in the field, however, mature heads formed 7-10 days earlier in 1991 compared to 1992 because of warmer temperatures. Fall Crop 1, seeded in July 1991, developed 4-inch seedlings 2.5 weeks earlier than in 1992 as above-normal temperatures persisted. Above-average temperatures in 1991 also permitted fall Crops 2 and 3 to develop normally compared to 1992 when normal temperatures prevailed and heads did not form.

Although maturity among the array of cultivars tested was controlled to a great extent by daylength and weather, differences were noted between cultivars that were probably due to genetic predisposition. Cultivars that were 5-6 days earlier than those reported for 1991 and 1992 (Table 6) were Crispino, Green Lake, Ithaca, Mission, Montello, and Salad Crisp. Cultivars displaying average maturity reported in the table were Duchesse, Frosty, Gemini, Mesa 659, Premier Great Lake, and Summertime. Cultivars that were 7-10 days later than average were Cerise and Great Lakes 659.

HARVEST SPAN

Uniformity of maturity can be measured by the harvest span or number of days to harvest at least 90% of the crop. Spring crops matured more evenly than fall crops. Forty-one percent of all cultivars planted in the spring of 1991 and 1992, at both sites, were harvested in 1 day (Table 7). The remaining 59% required a second harvest 2-6 days later. In the fall of 1991 and 1992, at both sites, 40% of all cultivars were harvested in 1day. Most of the single-day harvests in fall occurred in Crop 1. Crops 2 and 3 accounted for less than 10% of the single-day harvests. The remaining cultivars in fall crops required a second or third harvest during a 6-11 day span.

The uniformity of maturity, as measured by the harvest span, appears to be related to the speed of maturity. A fast maturing crop is more uniform than a slowly maturing crop. Specific cultivars such as Crispino, Green Lake, Ithaca, Minilake, Mission, Montello, and Premier Great Lake had uniform maturity in 50% or more of crops planted in spring. In fall, uniformity of maturity in 50% or more of crops planted was exhibited by Cerise, Mesa 659, Minilake, Mission, Montello, and Salad Crisp. With the exception of Salad Crisp, however, all these cultivars were tested only 1 year.

MANAGEMENT STRATEGIES

Transplanting vs. Direct Seeding

Transplanting of seedlings has several advantages over direct seeding for crop establishment. First, a more uniform stand can be established. The germination of seeds in a field can be erratic and is dependent upon available moisture in the soil, light, and temperature. Lettuce seeds require light during the induction phase of germination (Ryder 1979). If planted too deeply, germination will be inhibited. Uniform germination requires a uniform seedbed. Second, fields that are transplanted require less time for the growing crop, and harvest usually can be reduced to a single event in half of the plantings. Finally, transplanting eliminates the need for expensive thinning. This expense, however, must be weighed against the costs of producing or buying transplants.

Planting Dates

From the array of planting dates tested for spring and fall harvests, it is obvious that crisphead lettuce grown for spring harvest assures greater yields, uniformity of harvest, and quality. Among all cultivars grown in spring, the average yield at Windsor was 5,000 lb/A greater at Windsor and 7,000 lb/A at Mt. Carmel than crops grown for fall harvest. Further, more cultivars can be harvested in one picking in spring than in fall when two or three may be required. Single harvests may, however, not be suitable for all growing operations. For those who market directly to consumers through roadside stands, multiple harvests prolong availability of the lettuce. For growers interested in wholesale distribution, single harvests may be more cost effective. The desirable planting spans in spring and fall are rather narrow. Suitable crops were grown with spring transplanting dates between April 26 and May 9 and fall transplanting dates between July 24 and August 16. Transplanting crisphead lettuce from mid-May through late-July would be highly speculative due to bolting. Transplanting after August 15 would likely result in poor yield and quality because of smaller size, lower head density and failure to produce heads.

Seedlings grown in a greenhouse for spring transplanting required seeding 52-56 days before transplanting date. In fall, development of open-grown seedlings required 31-48 days and was dependent upon weather.

Selection of Cultivars

For spring production, Frosty consistently produced the greatest yield and quality among all cultivars tested. Heads weighing 1.0-1.3 lbs were uniform and compact. High quality, compact heads weighing 1.0-1.2 lbs were also produced by Duchesse, Crispino, and Gemini. The heads of Great Lakes 659 weighed 1.3-1.4 lbs, but ranged in compactness from loose to firm. Among small-headed cultivars, Minilake and Mission produced compact heads averaging 0.6-0.8 lb.

For fall production, Gemini and Summertime produced the most consistent quality among all cultivars, although head size varied from 0.9 lb in 1991 to 1.4 lb in 1992. Both cultivars are very similar in appearance, and 75% of plants produced firm to compact heads. Frosty and Crispino also produced satisfactory yields with about 70% of plants producing firm, marketable heads weighing 1.0-1.5 lb. Heads of most cultivars maturing in September and October were smaller and compactness ranged from loose to firm.

Site Selection

Average yields of all cultivars were about 1000 lb/A greater at Windsor than at Mt. Carmel in spring crops, and 5,000 lb/A greater in fall crops. Although the sandy soils at Windsor hold less water for crop utilization, they compact less and respond more rapidly to supplementary nitrogen fertilization at the time of head formation. Although irrigation requirements were modest in both 1991 and 1992 cropping seasons (applied only once in fall following transplanting), sandy soils may require additional applications during droughty periods.

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