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Witloof Chicory (Belgian Endive) and Radicchio Trials—1987-1988

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ABSTRACT

Witloof chicory seeded between June 10 and July 10 experienced less bolting than plants seeded in late May and very early June. Thinning to 4 inches within the row compared to 6 inches slowed maturity and reduced bolting in extra early to mid-maturing cultivars planted before June 10. Extra early to mid-maturing cultivars sown between June 10 and July 10 matured and were fully vernalized in the field by early November and were directly forced without intermediate cold storage. Roots, from earlier seeding that matured in September and October, required 10 days to 4 weeks cold storage to vernalize before forcing. Quality of chicory from roots harvested after December 15 declined because of injury to root crowns by cold.

Spring transplants of radicchio cultivars Medusa, Alto, and Augusto yielded 6,000 to 7,000 lb/A at Mt. Carmel on a loamy upland soil but only 3,000 lb/A at Windsor on a droughty, sandy terrace soil. In direct seeded fall plantings, 11 of 14 cultivars at Mt. Carmel and 6 of 14 at Windsor yielded more than 5,000 lb/A. At Mt. Carmel, Alto, Augusto, and Cesare yielded over 8,000 lb/A; 80% of plants produced marketable heads.

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Witloof chicory (*Chicorium intybus*), known in the United States as Belgian endive, was discovered inadvertently by a Belgian farmer in the mid-nineteenth century. Following perfection at the Brussels Botanical Gardens, it became widely grown in Western Europe and exported to the United States in 1911 (Sokolov 1985). Its popularity has grown and imports reached 3,000 tons in 1983. Witloof is now produced in New York State, and tests are being conducted in other parts of the country (Maynard & Howe 1986). The yellowish white heads, called chicons, are sold throughout the year with other salad greens.

Radicchio (*Chicorium intybus*), another chicory, originated in the Veneto region of Italy, the current source of most imports. Domestic production has now begun in California and Florida. The greenish bronze plant has a dense heart where leaves are dark red with creamy white veins. Unlike witloof, which must be forced, radicchio is grown in the field for direct harvest. Red, green, and variegated varieties are being developed for size, earliness of maturity, and mild flavor.

Since 1984, I have tested 40 varieties of witloof chicory, called cultivars, from Holland and Belgium to determine those best suited to Connecticut's soil and climate and two methods of forcing. The 40 cultivars, with a wide range of maturity, were grown at three sites. I demonstrated that witloof chicory could be grown in Connecticut on diverse soils and that during winter, mature roots could be forced to form chicons (Hill 1987, 1988). I also demonstrated that roots of extra early and early maturing cultivars became vernalized in the field and could be harvested in early December and forced directly without intermediate cold storage (Hill 1988).

In 1986 and 1987 I tested 25 cultivars of radicchio, mostly from Europe, to determine those best suited for Connecticut's soil and climate (Hill 1988). Most cultivars were seeded in the field and grown for fall harvest. Preliminary tests showed that two cultivars, Inca and Marina, transplanted in early May from a greenhouse, produced satisfactory yields.

In this bulletin I report experiments with witloof chicory to test the effect of spacing within the row on bolting (premature formation of flowers) and quality of forced chicons. I also report tests to determine whether extra early to mid-maturing cultivars have been sufficiently vernalized in the field by early November to allow direct forcing without intermediate cold storage.

Finally, I report tests of radicchio cultivars for highest yield and quality for a spring crop from transplants.

METHODS AND MATERIALS

Sites and soils.

Experiments with witloof chicory and radicchio 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 loamy upland soil with moderate moisture holding capacity.

Seeds and varieties.

Graded seed of witloof chicory and radicchio was obtained from several domestic and Dutch seed companies. Eleven cultivars of witloof chicory, including 10 grown in earlier trials (Hill 1987, 1988), provided an

array of maturity to accommodate forcing from September through March. They are classified by three periods of maturity: EXTRA EARLY: Arnova, Extrema, Karveel (new), Toner; EARLY-MIDDLE: Cerol, Regata, Zoom; LATE: Bea, Faro, Flash and Marriott.

Fourteen cultivars of radicchio, including 12 tested in 1986 and 1987 (Hill 1988), were grown for spring and fall harvest. Red-hearted cultivars included Adria, Alto (new), Augusto, Cesare, Dolphina, Giulio, Marina, Medusa (new), Otello, Palla Rossa, Red Devil, Ronette, and Silla. Crossara, a variegated green and red-hearted cultivar, was also grown.

Field management--witloof chicory.

Quality roots of witloof chicory require adequate phosphorus, potassium, and magnesium (Kruistum & Buishand 1982). Nitrogen fertilizer is generally excluded to prevent excessive top growth in the field and to discourage unfurling of outer leaves of the chicon during forcing. Adequate nitrogen is normally supplied by decaying organic matter in the soil. Both sites were fertilized with 150 lb/A P_2O_5 and 300 lb/A K_2O, supplemented with 140 lb/A MgO supplied as Epsom salts (860 lb/A). Addition of lime to attain a pH of 6.5 was unnecessary at both sites.

In 1987 and 1988, two crops of witloof chicory were planted at Windsor and Mt. Carmel to evaluate appropriate dates for planting to achieve late fall harvests for direct forcing without intermediate cold storage. The crops were seeded by hand at 2-3 week intervals on the following dates.

	Windsor	Mt. Carmel
1987		
Crop 1	May 28	June 11
Crop 2	June 17	June 23
1988		
Crop 1	June 20	June 21
Crop 2	July 13	July 12

In Crop 1 1987, four rows of each cultivar were planted 18 in. apart. When the plants were 3 in. high, two rows each were thinned to 4 and 6 in. within the row to achieve a density of 88,000 and 58,080 plants/A. In Crop 2 1987, and both crops 1988, plants were thinned to 4 in. The herbicide Pronamide (KERB 50W) was applied at 3 lb/A immediately after seeding and watered in.

Beginning in late August, roots of witloof chicory were tested periodically for maturity. The roots were split lengthwise and the fingernail-sized white patch just below the crown was examined. At maturity this tissue is 1/4 to 3/8 in. thick. Roots with patches thinner than 1/4 in. are immature and will not produce tightly furled chicons (Anon. 1984). Roots with patches thicker than 3/8 in. usually produce unmarketable heads or numerous crown shoots. The optimum root diameter is 1.25 to 2.5 in.

All crops were harvested sequentially according to maturity, extra-early through late. The dates of harvest span were as follows:

	Windsor	Mt. Carmel
1987		
Crop 1	Sept. 13-Nov. 27	Sept. 26-Dec. 16
Crop 2	Oct. 17-Dec. 1	Nov. 2-Dec. 26
1988		
Crop 1	Nov. 11-Dec. 3	Nov. 7-Dec. 1
Crop 2	Dec. 7-Dec. 8	Nov. 17-Dec. 31

In 1987, roots of Crop 2 at Mt. Carmel, harvested December 18-26, were used for direct forcing. In 1988, roots of the Crops 1 and 2 at Mt. Carmel and Crop 2 at Windsor, harvested November 7-December 27, were used for direct forcing. One row each of Faro, Flash, Bea and Marriott from Crop 2 at Mt. Carmel were harvested January 19 during a thaw and placed in cold storage.

During fall and winter harvest, whole plants were lifted and windrowed for 2 days. Wilted foliage was severed 1-1.5 in. above the root crown and roots were trimmed to 8 in. Roots less than 1 in. diameter or excessively forked or from bolted plants were discarded. The outer decayed leaves of winter-harvested roots were entirely removed.

Storage--witloof chicory.

The trimmed roots were placed in wire-mesh boxes to ensure ventilation, sterilized in 10% bleach solution for 3 min to control soft-rot bacteria and placed in cold storage at 30-32 F. Roots for direct forcing were dug, trimmed and placed in forcing beds without sterilization.

Forcing-witloof chicory.

The term "forcing" includes planting of roots, growing and harvesting of chicons. Roots were removed from storage or dug directly from the field and replanted in darkened enclosures in an unheated barn basement. The optimum temperature for forcing is 60 to 65 F (Kruistum & Buishand 1982). The unheated basement of the barn had a daily fluctuation of less than 2 F, but in mid-winter cooled to 42 F. The beds were heated to constant 65 F by electric cable, electric mat or circulating hot water in flexible pipes buried in the forcing mixture beneath the roots. The forcing chambers measured 8 x 3 x 1.5 ft or 3 x 4 x 1.5 ft in stackable wood or metal framed boxes. All chambers and boxes were well drained. The sides were insulated with styrofoam sheets 1 in. thick and the top

draped with 6-mil black plastic film to exclude light that would cause the chicons to become green and bitter.

I used the traditional European method of forcing with soil cover. A heating coil or flexible pipe was laid in a serpentine fashion on a 2 in. bed of 1:1 sand:peat mixture and covered with another 8 in. of the mixture. Heating mats were placed directly on the bottom of the box and protected with wire mesh mosquito screening and covered with 8 in. of sand:peat mixture. Sandy soil may also be used but may require sterilization to eliminate soil-borne diseases (Anon. 1985). Roots were planted about 30 degrees from vertical, in holes made by a dibble. Plant density was 25 to 30 roots/sq ft; less when forked roots were used. After planting the roots, the forcing mixture was watered thoroughly. The root crowns were then buried with another 4 in. of 1:2 sand:peat mixture and watered thoroughly.

The emerging chicons were usually ready to harvest in 3 to 4 weeks. The chicons and their attached roots were uncovered, the roots severed, and the outer leaves trimmed to remove adhering sand and peat. The chicons were graded according to weight and compactness. Grade A chicons were well-shaped, tightly furled and weighed over 2.5 oz. Grade B chicons were slender, loosely furled or weighed 1.0-2.5 oz. Grade B chicons are marketable, despite their flaws, but sell for less than Grade A. Chicons that were unfurled, misshapen or weighed less than 1 oz were discarded.

After harvest of the chicons, the roots were discarded and new roots were planted for the next forcing. Each mix was reused twice.

Field management--radicchio

The soil for the radicchio trials was fertilized in 1988 with 5-10-10 at a rate of 1250 lb/A. Addition of lime to attain a pH of 6.5 was unnecessary at both sites.

For the spring 1988 crop, seeds of all cultivars were sown March 25 in a greenhouse. Seedlings were grown in Promix BX in standard plastic pots measuring 2 5/8 in. x 2 1/4 in. x 2 5/16 in. joined in packs of 36. Water soluble 20-20-20 fertilizer (1 tbsp/gal) was added to the seedlings 3 weeks after germination. Seedlings were moved to a cold frame May 2 to harden and were set in the field May 9-13 at Windsor and May 16-17 at Mt. Carmel. Transplants were set 1 ft apart within rows 1.5 ft apart, a density of 29,040 plants/A. Weeds were controlled by cultivation.

For fall 1988 crop , seeds of all cultivars were sown in the field by hand on June 8 at Mt. Carmel and June 10 at Windsor. Two rows of each cultivar planted 1.5 ft apart were thinned to 1 ft within the row, a density of 29,040 plants/A. The herbicide Pronamide (KERB 50W) was applied at 3 lb/A immediately after seeding and watered in to control weeds.

In spring, mature heads were harvested June 29-August 2; in fall August 22-November 30. Outer green leaves were trimmed to expose the marketable red hearts.

RESULTS AND DISCUSSION

Witloof chicory

Effect of spacing on bolting.

Crop 1. To attain more even maturity in late-May 1987 plantings of witloof chicory, the spacing between plants within the row was narrowed from 6 to 4 in. The denser population provided greater competition between plants, slowed maturity and experienced less bolting. The results of narrow spacing (4 in.) vs. wide spacing (6 in.) are shown in Table 1. In a May 28 planting at Windsor, over all cultivars, 14% of widely-spaced plants bolted compared to 7% of narrowly-spaced plants. Bolting was most prominent in extra-early maturing Arnova, Extrema and Toner and early-mid maturing Zoom. Late maturing Bea, Faro, Flash and Marriott, had less bolting, and there was no difference between wide and narrow spacing. In a June 11 planting at Mt. Carmel only 2-3% of all cultivars bolted at both spacings.

Crop 2. In a June 17 planting at Windsor 4% of all cultivars bolted at the narrow spacing. In a June 23 planting at Mt. Carmel there was no bolting. In 1984 I observed 10%-20% bolting at Windsor in a mid-May planting thinned to 6 in. between plants (Hill 1987). The narrower spacing in 1987 reduced bolting in May-planted chicory. However, to achieve a very low level of bolting, it was necessary to delay planting at least until June 10.

Effect of spacing on chicon quality.

Crop 1. Spacing also affected the quality of chicons produced during forcing. At Windsor, total marketable chicons (Grades A & B) were 74% and 71% for wide and narrow spacings, respectively. Grade A predominated in roots from the narrow spacing while Grade B predominated in roots from the wide spacing, Table 1. At Mt. Carmel total marketable chicons were 76% at the wide and 83% at the narrow spacing. Grade A chicons predominated in both spacings. Grade A chicons comprised the 7 percentage point increase of total marketable in narrow vs. wide spacings.

Crop 2. The quality of Crop 2 was higher than Crop 1 at both Windsor and Mt. Carmel (Table 1). At Windsor, total marketable chicon yield was similar in the narrow-spaced Crops 1 and 2, but Grade A increased 4 percentage points in Crop 2. At Mt. Carmel, at narrow spacing, total marketable chicons increased 6 percentage points and Grade A increased 5 percentage points in Crop 2 compared to Crop 1. Thus, narrow spacing achieved a more uniform crop that matured slowly,

Table 1. Yield and quality of witloof chicory grown at wide and narrow spacing and forced with stored and field vernalized roots, 1987. The numbers in parenthesis are the number of forcings.

	Windsor						Mt. Carmel					
	Wide			Narrow			Wide			Narrow		
	oz./ chic.	mkt. %	bolt %	oz./ chic.	mkt. %	bolt %	oz./ chic.	mkt. %	bolt %	oz./ chic.	mkt. %	bolt %
CROP 1												
Arnova	-	-	19	-	-	7	2.6(2)	100	4	2.3(2)	96	4
Bea	-	-	1	2.3(1)	56	1	3.0(3)	76	0	3.7(2)	88	0
Extrema	1.7(2)	81	21	2.5(2)	87	10	2.3(2)	76	3	2.2(2)	99	3
Faro	2.5(2)	59	2	2.3(2)	57	1	3.4(1)	62	0	2.9(1)	58	0
Flash	-	-	10	2.5(2)	63	10	3.6(2)	59	0	3.9(2)	68	0
Lubert	1.2(2)	76	5	1.6(2)	82	1	-	-	12	-	-	7
Marriott	-	-	12	-	-	12	3.2(2)	75	2	2.8(4)	79	1
Regata	1.3(1)	52	14	1.6(2)	59	7	-	-	2	-	-	2
Toner	1.8(2)	90	27	2.0(2)	86	15	2.1(1)	100	1	2.6(2)	97	1
Zoom	2.1(1)	74	31	2.1(2)	75	8	2.6(1)	85	2	2.7(1)	77	9
AVERAGE	1.9	74	14	2.1	71	7	2.9	76	2	2.8	83	3
Grade A	2.3	31	-	2.4	37	-	3.3	49	-	3.2	56	-
Grade B	1.5	43	-	1.7	34	-	2.3	27	-	2.1	27	-
CROP 2				Narrow-Stored			Narrow-Stored			Narrow-Direct		
Arnova	-	-	-	2.3(1)	66	6	-	-	-	3.0(1)	100	-
Bea	-	-	-	2.4(2)	58	0	-	-	-	-	-	-
Cerol	-	-	-	-	-	-	3.5(1)	100	0	-	-	-
Extrema	-	-	-	4.4(1)	97	19	1.5(1)	92	0	2.6(1)	100	-
Faro	-	-	-	1.6(1)	54	2	1.9(1)	85	0	-	-	-
Karveel	-	-	-	-	-	0	3.3(1)	100	0	1.9(2)	100	-
Lubert	-	-	-	2.9(3)	52	2	2.0(2)	69	0	-	-	-
Marriott	-	-	-	3.2(1)	62	1	3.3(1)	95	0	-	-	-
Regata	-	-	-	3.7(1)	78	2	3.3(1)	100	0	-	-	-
Toner	-	-	-	2.8(1)	97	0	-	-	-	3.1(1)	99	-
Zoom	-	-	-	2.7(1)	71	5	-	-	-	3.6(1)	91	-
AVERAGE				3.1	72	4	2.8	89	0	3.0	98	-
Grade A				3.6	41	-	3.1	61	-	3.2	81	-
Grade B				2.5	31	-	2.0	28	-	2.3	17	-

decreased bolting, increased quality of chicons and increased total yield of roots.

Effect of site on chicon weight.

Crop 1. Chicon weight was little affected by wide or narrow spacing. However, there were distinct differences between Windsor and Mt. Carmel. Average chicon weights from roots grown at Mt. Carmel for both wide and narrow spacings were about 40% greater than from roots grown at Windsor. At Windsor, early maturing Extrema (narrow spacing) and late maturing Faro (wide spacing) and Flash (narrow spacing) had the greatest average chicon weights while at Mt. Carmel, late maturing Flash (wide and narrow spacing) and Bea (narrow spacing) had the greatest average chicon weights.

Crop 2. When thinned to only 4 inches, the average weight of chicons in all cultivars of roots grown at Windsor was 11% greater than grown at Mt. Carmel. The roots from Crop 2 at Windsor had larger diameters than in Crop 1 and accounted for the increase in chicon weight. At Windsor, extra early Extrema and early-mid forcing Regata had the greatest average chicon weights, while at Mt. Carmel the largest were from extra early maturing Karveel, early-mid maturing Cerol and Regata and late maturing Marriott.

Direct forcing without cold storage--1987.

Witloof chicory roots cannot be forced until they become vernalized and flower induction is initiated. In extra early and early maturing cultivars, vernalization may occur in 1 week of cold storage at 32 F (Huyskes 1961), but in middle and late maturing cultivars, vernalization may take as long as 8 weeks. Because cold storage is often difficult to find and expensive to construct, I began late season harvest of roots of extra early, early and mid-maturing cultivars for direct forcing. Preliminary tests in 1986 showed that vernalization occurred by early December. This allowed harvest and direct forcing without intermediate storage (Hill 1988). Roots directly planted in forcing beds produced chicons in the normal

Table 2. Yield and quality of witloof chicory forced with stored and field vernalized roots, 1988. The numbers in parenthesis are the number of forcings.

	Windsor				Mt. Carmel			
	Crop 1 *		Crop 2		Crop 1		Crop 2	
	oz./ chic.	Mkt. %	oz./ chic.	Mkt. %	oz./ chic.	Mkt. %	oz./ chic.	Mkt. %
EXTRA EARLY-MID MATURING; DIRECT FORCING								
Arnova	-	-	2.9(1)	98	3.8(2)	100	3.6(2)	100
Extrema	2.2(2)	97	4.6(1)	93	2.9(3)	94	3.8(3)	99
Karveel	2.0(2)	72	3.6(1)	100	3.6(1)	100	4.2(4)	98
Regata	2.2(2)	88	3.3(1)	96	3.4(1)	97	3.8(2)	100
Toner	2.6(2)	96	4.5(1)	98	3.1(3)	95	4.4(3)	100
Zoom	2.2(3)	77	3.5(2)	99	3.4(2)	99	5.0(3)	100
AVERAGE	-	-	3.8	98	3.2	97	4.2	99
Grade A	-	-	4.0	84	3.5	81	4.2	82
Grade B	-	-	2.7	14	2.3	16	4.2	17
LATE MATURING; STORED								
Bea	2.3(1)	81	3.4(2)	90	-	-	3.7(2)	68
Cerol	2.7(1)	83	4.1(2)	82	4.2(1)	99	-	-
Faro	-	-	2.9(2)	83	3.6(1)	53	2.9(1)	60
Flash	2.2(1)	81	3.5(1)	83	3.6(1)	65	2.9(1)	72
Marriott	2.3(2)	76	3.5(1)	88	3.6(1)	91	3.1(2)	61
AVERAGE	2.3**	83**	3.4	85	3.8	79	3.2	66
Grade A	2.9	29	3.6	51	4.3	44	3.5	41
Grade B	1.9	54	3.0	34	3.4	35	2.7	25

* Stunted crop, roots of all cultivars stored before forcing.

** Average for all cultivars in Crop 1.

3 to 4 weeks. In 1987, to further test the effect of direct forcing on chicon quality, roots of extra early to mid maturing cultivars were harvested in early December at Mt. Carmel and forced directly. The chicons were graded according to quality. The average weight of direct forced chicons of extra early and early-mid maturing cultivars was 11% greater than those those stored from 1 to 4 weeks, Table 1. The yield of marketable chicons from direct-forced roots was 98% compared to 89% in stored roots. More important, however, fully 81% of direct-forced roots produced Grade A chicons compared to 61% of stored roots. The average chicon weights of Toner, Zoom and Arnova were greatest. Thus, direct forcing in early December produced a modest increase in chicon weight and great improvement in quality.

Crop 1--1988. To determine whether vernalization was completed before early December, I began to harvest roots of extra early to mid-maturing cultivars at Mt. Carmel on November 7. The average weight/chicon of roots harvested in November was 3.2 oz; 97% produced marketable chicons (Table 2). Further, 81% of the marketable chicons were Grade A with an average chicon weight of 3.5 oz. Direct forced Arnova and Karveel had the greatest weight, 3.6-3.8 oz, with 100% of marketable chicons and 92% Grade A.

The late-maturing cultivars at Mt. Carmel required storage to complete vernalization. They averaged 3.8 oz/chicon and 79% marketable quality. Although Grade A chicons were large, 4.3 oz/chicon, only 44% of the crop was Grade A. Cerol had the greatest chicon weight, 4.2 oz/chicon; 99% of the chicons were marketable with 60% Grade A.

Plants developed poorly at Windsor. Seed sown in mid June, during a droughty period, germinated slowly. Heavy rains in July leached much of the applied nutrients, resulting in stunted tops and roots. At harvest 52% of the roots were less than 1 in. diameter and were discarded. The remaining roots, mostly 1.0-1.25 in. diameter, were stored and forced. They averaged only 2.3 oz/chicon and 83% marketable quality. Although tightly furled, only 29% were Grade A and weighed greater than 2.5 oz. Despite the general poor quality of the crop, Cerol and Toner exceeded 2.6 oz/chicon and were 83% marketable. The chicons of Extrema were small, 2.2 oz, but 97% were marketable.

Crop 2--1988. Results of direct forcing of extra early to mid maturing cultivars from both sites were outstanding. Average weights at Windsor and Mt. Carmel were 3.8 and 4.2 oz/chicon; 98% and 99% were marketable (Table 2). Over 80% of the chicons were Grade A. At Windsor, Extrema and Toner had the greatest chicon weights, 4.5-4.6 oz/chicon; at Mt. Carmel, average weights of Karveel, Toner and Zoom exceeded 4.2 oz/chicon.

The roots of late-maturing cultivars were stored. At Windsor, the average weight was 3.4 oz/chicon and at Mt. Carmel, 3.2 oz/chicon. At Windsor, 85% of the chicons were of marketable quality with 51% Grade A. At Mt. Carmel, 66% of the chicons were marketable with 41% Grade A. Although late-maturing cultivars seemed to produce poorer quality chicons than extra early to mid-maturing cultivars, the decline in quality was due to late harvesting and not a characteristic of the cultivars. At Windsor the late maturing cultivars were harvested December 16 and at Mt. Carmel, December 26. By December 16 Windsor had experienced over 40 nights with freezing temperatures, some as low as 0 F. By December 26 Mt. Carmel had experienced over 50 nights with freezing temperatures. Although the leaves of witloof chicory are not damaged by light frosts, very low temperatures cause the leaves to wither and rot in December. A root will produce a marketable chicon as long as the root crown is not damaged. Roots harvested at Mt. Carmel on December 26 had more damaged root crowns than those harvested December 16 at Windsor. Roots harvested January 21, 1989, during a mid-winter thaw, produced no marketable chicons.

Radicchio

Yield of spring transplants.

Preliminary tests in 1987 showed that spring transplants of Inca and Marina produced 78% and 69% marketable heads with yields of each exceeding 6,000 lb/A (Hill 1988). In 1988, results from transplanting 14 cultivars were less dramatic. At Windsor, the average yield of all cultivars was 2,189 lb/A and at Mt. Carmel, 4,249 lb/A, a 2-fold difference (Table 3). At Windsor, the smaller yields were due to drought in June followed by rapid leaching of nutrients during rainy July. Although yields exceeding 3,000 lb/A were achieved by Adria, Alto, Cesare, Medusa and Red Devil, they were small compared to yields of Inca and Marina in 1987. Despite low yields , Alto, Adria and Red Devil produced over 50% marketable heads. At Mt. Carmel, yield of Medusa exceeded 7,000 lb/A and Alto and Augusto exceeded 6,000 lb/A, comparable to 1987 yields. Alto, Silla and Medusa produced over 60% marketable heads, but the heads of Silla were small. Dolphina, Crossara and Otello produced the largest heads, but only 22% to 36% were marketable. At both sites Crossara, Dolphina, Marina, and Palla Rossa were most prone to bolting, a condition not experienced in spring 1987.

Yield of direct seeded crop in fall.

At Windsor, the average yield of all cultivars was 4,997 lb/A and at Mt. Carmel, 6,752 lb/A, a 35% difference. At Windsor, Alto yielded most, 7,514 lb/A and 87% marketable heads. The yields of Adria, Augusto,

Cesare, Crossara, Dolphina and Medusa exceeded 5,000 lb/A and over 50% of the plants produced marketable heads.

At Mt. Carmel, yields of 11 of 14 cultivars exceeded 5,000 lb/A. Alto, Augusto and Cesare yielded over 8,000 lb/A and over 80% marketable heads. Crossara, a variety producing large red and green variegated heads, yielded 8,320 lb/A but only 66% marketable heads. Although yields of Adria, Dolphina, Medusa and Red Devil were somewhat lower, over 70% of plants produced marketable heads.

Bolting in the fall crop of Crossara and Palla Rossa at Windsor was 26% and 21 %, respectively, and 18% and 16% at Mt. Carmel.

Table 3. Yield and quality of radicchio grown for spring and fall harvests, 1988

	Windsor				Mt.Carmel			
Cultivar	oz./ head	lb/ acre*	mkt. %	bolt %	oz./ head	lb/ acre*	mkt. %	bolt %
SPRING-TRANSPLANTS								
Adria	3.3	3122	52	10	5.4	3303	34	42
Alto	3.5	3884	62	4	5.2	6970	74	14
Augusto	3.6	1053	16	36	6.1	6382	32	40
Cesare	4.6	3485	42	28	5.2	5445	58	16
Crossara	5.2	2069	22	66	8.1	3231	22	70
Dolphina	5.4	1960	20	46	8.6	5627	36	54
Giulio	2.3	1343	32	12	4.4	3485	44	26
Marina	3.4	1597	26	48	5.0	2360	26	50
Medusa	3.6	3122	48	8	6.8	7623	62	22
Otello	5.2	762	8	12	9.5	689	4	46
Palla Rossa	4.3	1888	24	32	7.2	2868	22	62
Red Devil	3.6	3267	50	14	6.1	3993	36	30
Ronette	3.3	1815	30	18	5.6	2033	20	46
Silla	2.8	1416	28	0	4.2	5481	72	12
AVERAGE		2199				4249		
FALL--DIRECT SEEDED								
Adria	3.8	5266	76	5	5.6	7203	71	13
Alto	4.8	7514	87	2	6.1	9593	87	5
Augusto	4.0	5054	70	5	5.9	8740	84	2
Cesare	4.1	6102	82	2	5.5	8218	82	6
Crossara	6.1	5631	51	26	7.8	8370	66	18
Dolphina	4.8	5817	67	11	5.4	7302	74	11
Giulio	4.2	4600	61	10	4.1	4951	67	6
Marina	3.8	4261	62	14	5.8	7427	71	13
Medusa	4.4	5594	70	5	4.9	6966	78	1
Otello	3.4	3917	64	7	5.1	5748	62	6
Palla Rossa	4.6	3924	47	21	5.3	4657	48	16
Red Devil	4.1	4208	57	9	4.1	5382	72	1
Ronette	3.9	4105	58	6	3.7	4203	62	0
Silla	3.1	3964	71	4	4.0	5770	79	9
AVERAGE		4997				6752		

* Based on 29040 plants/A.

CONCLUSIONS

My experiments with witloof chicory and radicchio demonstrated that chicories can be successfully grown in the soils and climate of Connecticut. Witloof chicory seed sown between June 10 and July 10 produced plants less prone to bolting than seed sown in late May and very early June. Extra early to mid-maturing cultivars sown between June 10 and July 10 matured and were fully vernalized in early November and could be directly forced without intermediate cold storage. Very early to mid-maturing cultivars sown before June 10 for harvest in September and October were not vernalized in the field and required cold storage of 10 days (extra early-early maturing) to 4 weeks (mid maturing).

Thinning all plantings to 4 in. within the row slowed maturity, produced a heavier yield of even-aged roots and reduced bolting in extra early to mid-maturing cultivars planted before June 10. Quality of roots harvested after mid December declined because of injury to the crowns by cold. The root surface was also damaged when thin layers of frozen soil were broken from the root collar.

Spring transplanting of radicchio produced satisfactory yield in upland soils with moderate to high moisture holding capacities. On sandy soils subject to drought or severe leaching yields were lower, heads were smaller and fewer heads were marketable. Among all cultivars tested, Alto yielded most under adverse growing conditions. Spring grown radicchio can expand the availability of locally grown produce in the marketplace and opportunities for Connecticut growers. Production of radicchio by direct seeding for fall markets is simple and inexpensive. The yields of Alto, Augusto, Cesare and Crossara exceeded 8,000 lb/A in upland soil.

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REFERENCES

Anon. 1984. Instructions for growing and forcing chicory (Witloof) Enza Zaden, Enkhuizen, Holland. 4 p.

Anon. 1985. Handbook of growing and forcing of chicory witloof. Nunhems Zaden, Haelen, Holland. 19 p.

Hill, D.E. 1987. Witloof chicory (Belgian endive) trials-1985. Bulletin 843. Connecticut Agricultural Experiment Station, New Haven. 8 p.

Hill, D.E. 1988. The chicories witloof (Belgian endive) and radicchio trials--1986-1987. Bulletin 859. Connecticut Agricultural Experiment Station, New Haven. 12 p.

Huyskes, J.A. 1961. Witlooftrekken zonder degroud. Tuinbouw 24:297-300.

Kruistum, G. von and Buishand, Tj. 1982. Teelt en trek van witloof (Cultivation and forcing of witloof). Handbook No. 12. Proefstation AGV, Lelystad, Holland. 100 p.

Maynard, D.N. and Howe, T.K. 1986. Evaluation of specialty vegetable crops for production in west central Florida. Proceedings. Florida State Horticulture Society. 99:293-300.

Sokolov, R. 1985. The redheaded newcomer. Natural History. 4/85:35-37.

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