



High Tunnel Lettuce Variety Trial, Fall 2014

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Introduction

The purpose of this trial was to evaluate six butterhead lettuce varieties grown organically in a high tunnel. Butterhead lettuce is known for its sweet flavor and its large, tender and ruffled outer leaves surrounding a blanched heart. Growers can utilize niche markets by growing crops in high tunnels as they allow for season extension and out of season production. Growing more desirable varieties out of season allows growers to achieve higher prices.

Materials and Methods

The trial was planted in fall 2014 in a high tunnel (HT) production system at the ETREC Organic Crops Unit in Knoxville, TN. The tunnel was 96 ft long by 30 ft wide (Golden Pacific Windjammer Series 5000; Golden Pacific Structures, Cincinnati, OH), with a single-layer of plastic covering (Durafilm Super 4, AT Films, Inc., Edmonton, Alberta, CA) with 92% optical transmission and a North-South orientation.

Five-week old plants were transplanted 19 September. Six varieties were evaluated: 1) 'Alkindus' (Vitalis Organic Seeds, Salinas, CA), 2) 'Citrin' (SeedWay, Elizabethtown, PA), 3) 'Mirlo' (Vitalis Organic Seeds), 4) 'Nancy' (Johnny's Selected Seeds, Winslow, ME), 5) 'Neferin' (SeedWay) and 6) 'Sylvesta' (Johnny's Selected Seeds).

Each plot measured 10 ft long with 10 plants spaced 1 ft apart in a single row and rows spaced 3 ft apart. Fertilizer was applied at 90 lbs/acre (7.2 lbs N, 1.98 lbs P₂O₅, 3.7 lbs K₂O; Nature Safe 8-5-5) and incorporated in the planting rows prior to seeding. Drip irrigation was installed next to the planting row. Plants were irrigated when transplanted, and then irrigated twice per week to maintain soil moisture.

Multiple harvests occurred: 7 November ('Neferin'; 49 days after planting), 10 November ('Citrin'; 52 days after planting) and 13 November ('Alkindus', 'Mirlo', 'Nancy' and 'Sylvesta'; 55 days after planting). Yield by weight was calculated by plot, and then divided by the number of plants per plot to determine the average weight per plant. The weight per plant was used to determine the yield per high tunnel. Quality measurements were taken from four random, marketable plants and included plant height, diameter and core length.

The trial was set-up as a Randomized Complete Block Design using three replications with six varieties. Data was analyzed using PROC MIXED in SAS (Statistical Analysis System version 9.3 for Windows™, SAS Institute, Cary, NC, U.S.) to compare means. Significantly different means were compared using Fisher's Least Significant Difference test at an alpha level of 0.05.

Figure 1. Lettuce varieties in high tunnel trial (external and internal views), Knoxville, TN, Fall 2014.





Nancy
Johnny's Selected
Seeds



Nancy
Johnny's Selected
Seeds



Neferin
Seedway



Neferin
Seedway



Sylvesta
Johnny's Selected
Seeds



Sylvesta
Johnny's Selected
Seeds

Results

There were significant differences in total and marketable yield (Table 1). 'Nancy' yielded the greatest total weight and marketable weight, more than doubling or tripling the marketable weight per plot of all other varieties except 'Sylvesta', which had 3 lbs less marketable weight per plot. Unmarketable heads in 'Alkindus', 'Citrin', 'Mirlo' and 'Sylvesta' were due to loose head formation. Unmarketable heads of 'Neferin' bolted. Quality measurements also differed between varieties (Table 2). 'Neferin' had taller plant heights than all other varieties except 'Nancy' and 'Alkindus'. However, 'Alkindus' had greater head diameter than all other varieties except 'Citrin'. 'Neferin' had the greatest core length, which may be attributed to beginning stages of bolting. 'Nancy' and 'Neferin' had the highest height:diameter ratio, indicating a slightly oblong head shape.

Total and marketable yield per high tunnel (Table 3) were extrapolated from Table 1 yield results. Marketable head weights of 'Nancy' were nearly 1 lb, while the other five varieties ranged from 0.42-0.77 lbs per head. 'Nancy' yielded the greatest total and marketable cartons per high tunnel, with 100% marketable heads, followed by 'Sylvesta', with only two-thirds the number of cartons per tunnel as 'Nancy'. While 'Alkindus' also had 100% marketable heads, the head weight was less than half that of 'Nancy' causing much lower yields overall.

Table 1. High tunnel (HT) lettuce variety trial total and marketable yield (by number and weight) per plot, Knoxville, TN, Fall 2014.

	Total no. heads/plot	Total weight/plot (lbs)	Marketable no. heads/plot	Marketable weight/plot (lbs)
Alkindus (Vitalis)	9	3.90 d	9 a	3.90 c
Citrin (SeedWay)	9	4.15 cd	8 ab	3.82 c
Mirlo (Vitalis)	10	5.62 bc	6 bc	3.90 c
Nancy (Johnnys)	10	9.22 a	10 a	9.22 a
Neferin (SeedWay)	9	5.07 cd	4 c	2.31 c
Sylvesta (Johnnys)	9	6.91 b	8 ab	6.14 b
<i>p-value</i>	<i>0.4651</i>	<i>0.0002</i>	<i>0.0063</i>	<i>0.0005</i>
*Ten plants were planted per plot.				

Table 2. High tunnel (HT) lettuce variety trial plant height, diameter, core length and height:diameter, Knoxville, TN, Fall 2014.

	Average height* (in)	Average diameter (in)	Average core length (in)	Height: Diameter
Alkindus	5.19 abc	5.51 a	2.71 bc	1.00 b
Citrin	4.72 bc	5.12 ab	2.49 b	0.94 b
Mirlo	4.46 c	4.66 c	1.44 d	0.96 b
Nancy	5.31 ab	4.72 bc	2.17 bc	1.17 a
Neferin	5.84 a	4.66 c	3.19 a	1.17 a
Sylvesta	4.59 bc	4.92 bc	1.62 cd	0.97 b
<i>p-value</i>	<i>0.0245</i>	<i>0.0048</i>	<i>0.0012</i>	<i>0.0049</i>
* All head characteristics are an average of four heads per plot.				

Table 3. High tunnel (HT) lettuce variety trial marketable head weight, marketable yield (number of heads and weight) per HT, marketable cartons per HT and % marketable yield, Knoxville, TN, Fall 2014.

	Marketable head weight (lbs)	Marketable no. heads/HT [^]	Marketable weight/HT (lbs)	Marketable cartons* / HT	% Marketable (by no.)	% Marketable (by weight)
Alkindus	0.42 d	2016 a	847 c	42 c	100 a	100 a
Citrin	0.50 d	1656 ab	828 c	41 c	80 ab	90 ab
Mirlo	0.68 bc	1224 bc	832 c	42 c	57 bc	70 bc
Nancy	0.92 a	2160 a	1987 a	99 a	100 a	100 a
Neferin	0.55 cd	936 c	515 c	26 c	47 c	50 c
Sylvesta	0.77 ab	1728 ab	1331 b	67 b	83 ab	90 ab
<i>p-value</i>	<i>0.0002</i>	<i>0.0063</i>	<i>0.0005</i>	<i>0.0005</i>	<i>0.0118</i>	<i>0.0086</i>
[^] HT calculations: 90 plants per row, 4 rows per bed, 5' center beds= 6 beds per HT= 24 rows per HT						
* 20 lbs per carton						

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High Tunnel Arugula Variety Trial, Fall 2014



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Introduction

Arugula performs best in cool temperatures and is typically grown from seed in early spring or late fall. Leaves are bunched when harvested and must be kept in cool, humid conditions to maintain shelf-life. There are two types of arugula that are generally grown. The salad type has broad leaves, a vigorous growth rate and is generally found in U.S. markets. The wild type has lobed leaves, a slower growth rate and is typically found in European markets. The purpose of this trial was to evaluate yield and quality of three arugula varieties grown organically in a high tunnel.

Materials and Methods

The trial was planted during fall 2014 in a high tunnel (HT) production system at the ETREC Organic Crops Unit in Knoxville, TN. The tunnel was 96 ft long by 30 ft wide (Golden Pacific Windjammer Series 5000; Golden Pacific Structures, Cincinnati, OH), with a single-layer of plastic covering (Durafilm Super 4, AT Films, Inc., Edmonton, Alberta, CA) with 92% optical transmission and a North-South orientation.

Three varieties were evaluated: 1) 'Astro' (SeedWay, Elizabethtown, PA), 2) 'Grazia' (Vitalis Organic Seeds, Salinas, CA) and 3) 'Tricia' (Vitalis Organic Seeds). Plants were direct seeded by hand 23 September at a rate of 30-50 seeds per foot. Replications were 30 ft long and 2 ft wide flat-ground beds. Each bed contained three rows spaced 1 ft apart. Each row contained one variety.

Fertilizer was applied at 90 lbs/acre (7.2 lbs N, 1.98 lbs P₂O₅, 3.7 lbs K₂O; Nature Safe 8-5-5), and was incorporated in the planting rows prior to seeding. Two lines of drip irrigation were installed between the planting rows. Plants were irrigated when seeded, and then irrigated twice per week to maintain soil moisture.

Harvest occurred on 6 November (44 days after planting) and yield weighed by plot. Leaves were cut just above the soil during harvests. The weight per plot was used to determine the weight per high tunnel.

The trial was designed as a Randomized Complete Block Design using three replications and three varieties. Data were analyzed using PROC MIXED in SAS (Statistical Analysis System version 9.3 for Windows™, SAS Institute, Cary, NC) in order to compare means. Significantly different treatment means were compared using Fisher's Least Significant Difference test at an alpha level of 0.05.

Results

There were significant differences in yield and leaf size between the three varieties. 'Astro' was a larger leaf variety (American, salad-type), while 'Grazia' and 'Tricia' were highly dissected and slender (European, wild type) (Figure 1). The leaf sizes (length, width and the length:width ratio) were significantly different, and these differences in leaf sizes contributed to yield differences (Table 1). 'Grazia' and 'Tricia' leaves were approximately 40% shorter than those of 'Astro,' while leaf width varied among all three cultivars with 'Astro' having the largest width (2.67 in), followed by 'Grazia' (1.64 in) and then 'Tricia' (0.97 in). Length:width ratios were similar for 'Astro' and 'Grazia,' but larger for 'Tricia'. 'Astro' exceeded the estimated number of cartons per high tunnel (over 100 cartons/tunnel), while 'Grazia' and 'Tricia' were below yield standards (<10 cartons/tunnel), as these standards are based on the American-type. However, the European-types are gaining popularity in the American market and, therefore, fulfill a market niche.

Figure 1. Arugula varieties in high tunnel trial, Knoxville, TN, Fall 2014.





'Astro'
SeedWay



'Grazia'
Vitalis Organic Seeds



'Tricia'
Vitalis Organic Seeds

Table 1. High tunnel (HT) arugula variety trial total yield, leaf length, width and length:width, Knoxville, TN, Fall 2014.

Variety	Total weight/plot (lbs)*	Total weight/HT^ (lbs)	Total cartons ⁺ /HT	Average leaf length (in)	Average leaf width (in)	Leaf length: width (in)
Astro (SeedWay)	13.74 a	825 a	103 a	8.96 a	2.67 a	1.36 b
Grazia (Vitalis)	1.07 b	64 b	8 b	5.29 b	1.64 b	1.27 b
Tricia (Vitalis)	1.18 b	71 b	9 b	5.19 b	0.97 c	2.11 a
<i>p-value</i>	<i><.0001</i>	<i><.0001</i>	<i><.0001</i>	<i>0.0009</i>	<i>0.0054</i>	<i>0.0113</i>

* Each plot measured 30 ft long.

^ HT calculations: HT 30 ft wide/1 ft row spacing + foot paths=20 rows per HT;
90 ft long rows (each 30 ft plot multiplied by 3 to achieve a 90 ft row)= lbs per row
multiplied by 20 rows= lbs per HT

+ Each carton contains 8 lbs.

High Tunnel Endive Variety Trial, Fall 2014



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Introduction

High tunnels allow endive to be grown earlier in the spring and later in the fall helping to extend the production season and harvests. Endive is in the chicory family along with its cousins, radicchio and escarole. There are two main types of endive that are grown for production- Belgian and curly endive. Belgian endive is extremely pale yellow, as it is grown in the dark, which prevents chlorophyll from developing and keeps the leaves pale. As the name implies, curly endive produces a medium, curly leaf for summer and fall production. The purpose of this trial was to evaluate two curly endive varieties grown organically in a high tunnel.

Materials and Methods

The trial was planted in fall 2014 in a high tunnel (HT) production system at the ETREC Organic Crops Unit in Knoxville, TN. The tunnel was 96 ft long by 30 ft wide (Golden Pacific Windjammer Series 5000; Golden Pacific Structures, Cincinnati, OH), with a single-layer of plastic covering (Durafilm Super 4, AT Films, Inc., Edmonton, Alberta, CA) with 92% optical transmission and a North-South orientation.

Six-week old plants were transplanted 9 September. Two varieties were evaluated: 1) 'Dubuissou' (Johnny's Selected Seeds, Winslow, ME and Vitalis Organic Seeds, Salinas, CA) and 2) 'Rhodos' (SeedWay, Elizabethtown, PA). 'Dubuissou' was included from two seed sources to evaluate performance differences, if any.

Each plot measured 20 ft long with 20 plants spaced 1 ft apart in a single row and rows spaced 2 ft apart. Fertilizer was applied at 90 lbs/acre (7.2 lbs N, 1.98 lbs P₂O₅, 3.7 lbs K₂O; Nature Safe 8-5-5) and incorporated in the planting rows prior to seeding. Drip irrigation was installed next to the planting row. Plants were irrigated when transplanted, and then irrigated twice per week to maintain soil moisture.

Harvest occurred 6 November (58 days after planting). Yield was weighed by plot, and then divided by the number of plants to determine the weight per plant. The weight per plant was used to determine the overall yield (by weight) per high tunnel according to Oregon State University standards (<http://nwrec.hort.oregonstate.edu/endive.html>). The number of plants per high tunnel and weight per high tunnel is based on 6 ft bed centers with 3 rows per bed and plants spaced 1 ft apart in-row. Quality measurements were taken from four random plants per plot and included plant height, diameter and core length.

The trial was designed as a Randomized Complete Block Design using three replications and two varieties. Data were analyzed using PROC MIXED in SAS (Statistical Analysis System version 9.3 for Windows™, SAS Institute, Cary, NC) in order to compare means. Significantly different means were compared using Fisher's Least Significant Difference test at an alpha level of 0.05.

Results

There were significant differences in yield and quality between the two varieties, 'Dubuissou' and 'Rhodos'. There were no significant differences between the seedlots for 'Dubuissou' from Johnny's and Vitalis. Yield per plot, yield per plant, yield per HT and cartons per HT were greater for 'Dubuissou', with nearly 750 more lbs of endive per tunnel than 'Rhodos' (Table 1). Plant height and diameter measurements were greater for 'Dubuissou' (Table 2), with an average of 2-inches taller and 1.5-inches wider heads. These larger head sizes contribute to the greater yields achieved by 'Dubuissou'. Overall, 'Rhodos' was a smaller growing variety but the marketable number of plants was equal to 'Dubuissou' (20 plants/plot and 1,350 plants/HT; data not shown). There was no difference between total and marketable yield.

Table 1. High tunnel (HT) endive variety trial total and marketable yield, Knoxville, TN, Fall 2014.

Variety	Total and marketable weight/ plot (lbs)	Total and marketable weight/plant (lbs)	Total and marketable weight/HT* (lbs)	Total and marketable cartons^/HT
Dubuissou (Johnny's)	32.44 a	1.62 a	2190 a	109 a
Dubuissou (Vitalis)	32.44 a	1.62 a	2190 a	109 a
Rhodos (SeedWay)	21.35 b	1.07 b	1441 b	72 b
<i>p-value</i>	<i>0.0011</i>	<i>0.0011</i>	<i>0.0011</i>	<i>0.0011</i>
* HT yield: 30 ft wide and 90 ft long, 6 ft centers, 3 rows per bed=5 beds/HT; 90 ft row/1 ft in-row spacing = 90 plants/row * 3 rows/bed = 270 plants per bed * 5 beds = 1350 plants per HT ^20 lbs. per carton				

Table 2. High tunnel (HT) endive variety trial plant height, diameter, core length and height:diameter, Knoxville, TN, Fall 2014.

Variety	Average* head height (in)	Average head diameter (in)	Average core length (in)	Head height: diameter
Dubuissou	7.25 a	12.08 a	1.52 a	0.24 a
Dubuissou	7.88 a	12.75 a	1.57 a	0.24 a
Rhodos	5.50 b	10.96 b	1.27 b	0.20 b
<i>p-value</i>	<i>0.0033</i>	<i>0.0154</i>	<i>0.0285</i>	<i>0.0285</i>
* All head characteristics are an average of four heads per plot.				

Figure 1. Endive varieties in high tunnel trial (external and internal views), Knoxville, TN, Fall 2014.



'Dubuisson'
Johnny's Selected Seeds and Vitalis Organic Seeds



'Rhodos'
SeedWay

High Tunnel Carrot Variety Trial, Fall 2014



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Introduction

The purpose of this trial was to evaluate five carrot varieties grown organically in a high tunnel. Carrots grow well in the fall and can be carried over for spring harvest. There are several types of carrots: Nantes, Chantenay, Imperator, and Danvers. This trial evaluated Nantes as they are a fast maturing, orange rooted carrot. Nantes carrots are prized for their sweet flavor, crisp texture and inconspicuous core. The ability to overwinter carrots in a high tunnel offers growers the opportunity to harvest carrots throughout the winter and early spring.

Materials and Methods

The trial was planted during fall 2014 in a high tunnel (HT) production system at the ETREC Organic Crops Unit in Knoxville, TN. The tunnel was 96 ft long by 30 ft wide (Golden Pacific Windjammer Series 5000; Golden Pacific Structures, Cincinnati, OH), with a single-layer of plastic covering (Durafilm Super 4, AT Films, Inc., Edmonton, Alberta, CA) with 92% optical transmission and a North-South orientation.

Five Nantes varieties were evaluated: 1) 'Jeanette' (Vitalis Organic Seeds, Salinas, CA), 2) 'Mokum' (SeedWay, Elizabethtown, PA), 3) 'Napoli' (Johnny's Selected Seeds, Winslow, ME and SeedWay), 4) 'Nelson' (SeedWay) and 5) 'Yaya' (Johnny's Selected Seeds). 'Napoli' was included from two seed sources to evaluate performance differences, if any.

Plants were direct seeded by hand 11 September with seed spacing of 1-2 in. Replications were 15 ft long and 2 ft wide flat-ground beds. Each bed contained three rows spaced 1 ft apart. Each row on the bed contained one variety.

Fertilizer was applied at 90 lbs/acre (7.2 lbs N, 1.98 lbs P₂O₅, 3.7 lbs K₂O; Nature Safe 8-5-5), and was incorporated in the planting rows prior to seeding. Two lines of drip irrigation were installed between the planting rows. Plants were irrigated when seeded, and then twice per week to maintain soil moisture.

Harvest occurred on 10 December (90 days after planting) and yield calculated in a five-foot sub-plot within each 15-foot plot. The weight per sub-plot was used to determine the cartons (48 1-lb bunches per carton) per high tunnel. Each carrot was measured and categorized by size: 0-3 inches, 3-6 inches and greater than 6 inches. Carrots in each size category were counted and weighed (lbs).

The trial was set-up in a Randomized Complete Block Design using three replications with five varieties. Data was analyzed using PROC MIXED in SAS (Statistical Analysis System version 9.3 for Windows™, SAS Institute, Cary, NC, U.S.) to compare means. Significantly different means were compared using Fisher's Least Significant Difference test at an alpha level of 0.05.

Figure 1. Carrot varieties in high tunnel trial, Knoxville, TN, Fall 2014.





Results

'Nelson' had the highest total and marketable yield by number (Table 1), with higher yields than all other varieties except 'Napoli' (SeedWay) (total) and 'Jeanette' (total and marketable). 'Napoli' (SeedWay) had the highest total and marketable yield by weight, and nearly 50 marketable cartons per tunnel (Table 2), with higher yields than all other varieties except 'Nelson'. 'Napoli' (SeedWay) had better germination rates compared to 'Napoli' (Johnny's) contributing to greater number and weight of total and marketable carrots (data not shown). Percents within each size class for number and weight of carrots did not differ by variety, but the majority of carrots fell into the 3-6 inch size class (Table 3). Very few unmarketable carrots were harvested from the plots and were the result of deformed roots (Figure 2).

Figure 2. Umarketable carrots in high tunnel variety trial, Knoxville, TN, Fall 2014.



Table 3. High tunnel (HT) carrot variety trial percent yield (by number and weight) by size class, Knoxville, TN, Fall 2014.

Carrot size classes

Table 1. High tunnel (HT) carrot variety trial total and marketable yield (by number and weight) per plot, Knoxville, TN, Fall 2014.

	Total no.	Total weight (lbs)	Marketable no.	Marketable weight (lbs)
Jeanette (Vitalis)	43 ab	3.05 bc	41 ab	2.83 bc
Mokum (SeedWay)	38 bc	3.27 bc	33 b	2.79 bc
Napoli (Johnny's)	24 bc	2.28 c	23 b	2.09 c
Napoli (SeedWay)	42 abc	4.78 a	39 b	4.30 a
Nelson (SeedWay)	59 a	3.82 ab	58 a	3.75 ab
Yaya (Johnny's)	24 c	2.28 c	22 b	2.09 c
<i>p-value</i>	<i>0.0161</i>	<i>0.0258</i>	<i>0.0144</i>	<i>0.0336</i>

*Each harvested plot measured 5-ft long.

Table 2. High tunnel (HT) carrot variety trial total and marketable yield (by carton) per tunnel, Knoxville, TN, Fall 2014.

	Total cartons ^z /HT [^] (lbs)	Marketable cartons/HT (lbs)
Jeanette	34 bc	31 bc
Mokum	36 bc	31 bc
Napoli (Johnny's)	25 c	23 c
Napoli (SeedWay)	53 a	48 a
Nelson	43 ab	42 ab
Yaya	25 c	23 c
<i>p-value</i>	<i>0.0258</i>	<i>0.0336</i>

^z1 carton= 48 1-lb bunches

[^]Calculations for ideal spacing of carrots to fill one 30 ft x 96 ft high tunnel:

1 row= 90 ft=1080 inches/2-inch in-row spacing= 540 plants/row

90 ft row/5 ft plots per variety= 18 plots per row

6 ft beds with 6 rows/bed and 1-ft foot paths= 5 beds per tunnel x 6

rows/bed= 30 rows/tunnel

Variety	% 0-3 in. carrots (by no.)	% 0-3 in. carrots (by wt.)	% 3-6 in. carrots (by no.)	% 3-6 in. carrots (by wt.)	% 6-9 in. carrots (by no.)	% 6-9 in. carrots (by wt.)
Jeanette	3	2	60	40	37	57
Mokum	8	3	61	52	31	45
Napoli (Johnny's)	3	1	68	55	30	44
Napoli (SeedWay)	5	1	71	62	24	37
Nelson	12	4	77	76	11	20
Yaya	4	2	74	70	22	29
<i>p-value</i>	<i>0.4968</i>	<i>0.5162</i>	<i>0.3819</i>	<i>0.1781</i>	<i>0.4144</i>	<i>0.2402</i>