



## Winter Lettuce Variety Trial

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### **Introduction**

Lettuce grows extremely well in the Pacific Northwest. Mild winter temperatures and the use of season extenders such as hoopouses and cloches make growing lettuce for fall, winter and spring harvest a potential market niche for local farmers. Winter lettuce can be a good addition for direct market farmers who need additional crops during the off-season. In 2003, we began to screen lettuce varieties for suitability for winter production in western Washington. For this study we selected a range of crisphead, leaf, butterhead, French and romaine lettuce varieties, and also included early, middle, and late maturing varieties. Lettuce harvested from this study was evaluated by Kath Sherman, Washington State University Vancouver Food Service Director. Kath also served the lettuce in the campus cafeteria salad bar.

### **Materials and Methods**

On August 13, 2003, 23 varieties of lettuce were seeded into 72-cell seedling trays in the greenhouse. On October 15, lettuce starts were transplanted into the hoopouse and the field. The site used for this study is certified organic and was maintained accordingly. We planted the lettuce under three field conditions: field hoopouse with compost; cloche with compost; and cloche without compost. The field hoopouse was unheated and unlit. Compost was applied at a rate of 3-inches in the hoopouse and in the field, and was tilled into the soil. Beds formed in the hoopouse and in the field were 4 feet wide by 36 feet long. Cloches were made by placing 8-gauge wire hoops over the beds in the field and covering them with Agribon AG-19, a thin spun-bonded polypropylene that lets in light and water, and provides up to 4<sup>o</sup> F of frost protection. This product has a weight of 0.55 oz/sq yd. Paper mulch was applied under the cloches and provided excellent weed control throughout the study. In the hoopouse, paper mulch was not used and instead we hand weeded several times throughout the course of this study. Trickle tape was installed in the hoopouse for irrigation while beds under cloches received natural precipitation. On October 28, Agribon AG-19 (0.55 oz/sq yd) was installed inside the hoopouse to cover plants during periods of freezing temperatures.

Lettuce was harvested once a week from November 18 until December 16. We measured total weight (kg), trimmed weight (kg), bunched circumference (cm), and bunched length (cm) for each variety from all three beds. Lettuce was weighed immediately after harvest to determine total weight. Damaged unmarketable outside leaves were removed, and lettuce was reweighed to measure trimmed weight. A rubber

band was placed around the lettuce head to replicate how lettuce is sold at a grocery store, and the circumference was measured. The length of the bunched head was also measured.

After harvest, we evaluated taste, size and marketability of each variety grown in the hoophouse and in the cloche with compost. We measured quality on a scale of 1-5 where 1=poor, 3=ok, and 5=excellent. Marketability was determined by size and ranged from very small to large. Very small or small head size was considered unmarketable.

A HOBO H6 soil temperature probe was used to measure temperatures at the soil level inside the hoophouse and in the cloche. In the cloche, temperature was measured on the surface of the paper mulch and below the paper mulch at the soil level. Finally, as part of a senior science project, a high school student measured NO<sub>3</sub>-nitrogen released in the lettuce beds under the cloche with and without compost addition. Samples were collected once a week from October 13 through November 17. At each sample date, six soil cores were collected randomly throughout the plot and bulked. A 250 ml sub sample was sent to a soil testing laboratory for analysis.

## Results and Discussion

**Yield.** Lettuce varieties grown in the hoophouse had significantly greater total and trimmed (marketable) weights as compared to those varieties grown in the cloche (Table 1). In general, varieties that produced the greatest total head weights also produced the greatest marketable head weight. In the cloche, total and trimmed head weights differed significantly with the addition of compost, and compost resulted in greater total and marketable head weight. Varieties that produced the largest marketable head weight overall were Trout's Back, Oakleaf Redder Ruffled, Winter Density, Austrian Greenleaf, Romaine Dark Green, and Brunia.

Lettuce varieties also varied significantly in bunched length and circumference, and there were significant differences between varieties grown in the hoophouse and those grown in the cloche (Table 2). However, there were no significant differences between lettuce varieties grown with and without compost in the cloche. Varieties that produced the greatest head length overall were Bronze Arrowhead, Oaky Red Splash, Cracoviensis, Brunia, Trout's Back, and Brown Golding. Varieties that produced the greatest head circumference overall were Victoria, Austrian Greenleaf, New Red Fire, Trout's Back, Bronze Arrowhead, and Cardinale.

**Marketability.** Lettuce head size was rated from very small to large, and graded as marketable or not marketable based on size. Lettuce heads of medium and large size were considered marketable while small and very small heads were not considered marketable. Head size essentially did not change over the 4-week harvest period from November 18 through December 16 (Table 3). More marketable heads were produced in the hoophouse (73%) than in the cloche (10%), and compost addition in the cloche did not affect marketable head size. In this trial, no varieties produced very large heads. Head size of winter-grown lettuce may not be considered a critical factor for determining

variety suitability for winter production if growers are able to bunch two to three heads together for marketing purposes.

Lettuce varieties were rated based on flavor and overall were found to be above average (Table 4). There were significant differences in the flavor ratings among varieties in the hoophouse but not in the cloche. Flavor of varieties did not change due to hoophouse or cloche production, that is, in general varieties that were the most flavorful in the hoophouse were also the most flavorful in the cloche. Varieties that were rated with the highest flavor overall were Winter Density, Oakleaf Redder Ruffled, Brown Golding, Blushed Butter Oak, Sanquine Ameliore and Yugoslavian Red. Varieties that were rated with the lowest flavor were Brunia, Austrian Greenleaf, Bijou, and Outredgeous. All lettuce varieties were given to the WSU Vancouver Food Service Director for evaluation. She found them all acceptable and served them in her salad bar.

**Temperature.** Mean temperature throughout this study period was 8° C (46° F), while maximum temperature was 20° C (68° F) and minimum temperature was -3° C (27° F). High temperatures inside the hoophouse were approximately 5° C (10° F) greater than temperatures in the cloche. While low temperatures were essentially the same (Figure 1). In the cloche, we measured temperatures on top of and underneath the paper mulch. In general, temperatures under the mulch tended to be less extreme than temperatures on top of the mulch. That is, on top of the paper mulch maximum daily temperatures tended to be higher and minimum daily temperatures tended to be lower than under the mulch.

**Compost.** Soil from cloche plots with and without compost was first collected on October 13 and NO<sub>3</sub>-nitrogen levels were found to be 15 lbs/acre in both plots (Table 5). The following week there was a sharp increase in NO<sub>3</sub>-nitrogen from these plots, and the plots with compost had a six-fold increase in NO<sub>3</sub>-nitrogen as compared to a two-fold increase in plots that had no compost. In the plots with no compost soil NO<sub>3</sub>-nitrogen levels declined each week, and the final NO<sub>3</sub>-nitrogen level (7 lbs/acre) was half of the starting value. In plots with compost, soil NO<sub>3</sub>-nitrogen levels fluctuated weekly, and levels were generally greater than soil with no compost. These results indicate that NO<sub>3</sub>-nitrogen is released into the soil from winter-applied compost.

## Conclusions

Winter lettuce is well-suited for production in western Washington and can be successfully grown in cloche or hoophouse systems. An unheated and unlit hoophouse can be used to produce higher yielding lettuce, however the flavor quality of varieties grown in a hoophouse appear to be the same as in a cloche. In this study varieties that produced the greatest yield and the best flavor were Oakleaf Redder Ruffled and Winter Density.

**Table 1.** Mean head weight (kg) and trimmed weight (kg), of 23 lettuce varieties harvested weekly from November 18 through December 16 at WSU Vancouver REU.

	Total Weight (kg)				Trimmed Weight (kg)			
	HH	Cloche			HH	Cloche		
Variety	With C	With C	W/O C	Avg.	With C	With C	W/O C	Avg.
Austrian Greenleaf	1.02	0.44	0.40	0.62	0.96	0.40	0.38	0.58
Bijou	0.32	0.24	0.28	0.28	0.30	0.14	0.24	0.23
Blushed Butter Oak	0.94	0.38	0.32	0.55	0.80	0.32	0.24	0.45
Bronze Arrowhead	0.92	0.52	0.48	0.64	0.89	0.47	0.30	0.55
Brown Golding	0.62	0.18	0.18	0.33	0.56	0.14	0.08	0.26
Brunia	0.88	0.60	0.58	0.69	0.82	0.46	0.39	0.56
Cardinale	1.06	0.50	0.42	0.66	0.94	0.30	0.34	0.53
Cracoviensis	1.16	0.52	0.54	0.74	0.80	0.38	0.36	0.51
De Morges Braun	0.94	0.14	0.16	0.41	0.74	0.08	0.08	0.30
Kweik	1.06	0.40	0.28	0.58	0.88	0.22	0.10	0.40
New Red Fire	0.78	0.32	0.48	0.53	0.72	0.26	0.40	0.46
Oakleaf Redder								
Ruffled	1.26	0.54	0.32	0.71	1.18	0.44	0.20	0.61
Oaky Red Splash	1.20	0.34	0.26	0.60	1.08	0.28	0.24	0.53
Outredgeous	0.58	0.32	0.18	0.36	0.54	0.20	0.16	0.30
Reine Des' glaces	1.00	0.38	0.42	0.60	0.84	0.32	0.38	0.51
Romaine Dark Green	1.36	0.50	0.32	0.73	1.20	0.26	0.26	0.57
Sanquine Ameliore	0.44	0.28	0.16	0.29	0.38	0.22	0.12	0.24
Simpson Elite	0.90	0.42	0.26	0.53	0.78	0.32	0.20	0.43
Tom Thumb	0.58	0.26	0.22	0.35	0.42	0.12	0.10	0.21
Trout's Back	1.42	0.40	0.32	0.71	1.27	0.34	0.28	0.63
Victoria	1.20	0.38	0.46	0.68	0.92	0.26	0.34	0.51
Winter Density	1.08	0.60	0.34	0.67	1.02	0.48	0.26	0.59
Yugoslavian Red	0.64	0.26	0.18	0.36	0.40	0.24	0.14	0.26
Overall Mean	0.93	0.39	0.33	0.55	0.80	0.29	0.24	0.44
P Value	0.0000	0.0081	0.0000		0.0000	0.0008	0.0000	
Column	A	B	C		A	B	C	
Comparison	AvsB	BvsC	AvsC		AvsB	BvsC	AvsC	
Comparative P value	0.0000	0.0086	0.0000		0.0000	0.0297	0.0000	

**Table 2.** Mean head length (cm) and circumference (cm) of 23 lettuce varieties harvested weekly from November 18 through December 16 at WSU Vancouver REU.

Variety	Length (cm)				Circumference (cm)			
	HH	Cloche			HH	Cloche		
	With C	With C	W/O C	Avg.	With C	With C	W/O C	Avg.
Austrian Greenleaf	26.1	15.0	15.2	18.8	37.9	25.3	30.4	31.2
Bijou	20.2	13.3	14.2	15.9	24.8	15.3	17.2	19.1
Blushed Butter Oak	23.8	17.2	15.7	18.9	36.0	23.1	18.4	25.8
Bronze Arrowhead	33.4	24.0	21.6	26.3	34.8	26.9	22.6	28.1
Brown Golding	24.2	19.7	16.5	20.1	26.2	18.3	11.8	18.8
Brunia	27.6	17.8	16.9	20.8	36.3	19.7	19.5	25.2
Cardinale	23.6	14.1	18.2	18.6	39.4	19.7	23.5	27.5
Cracoviensis	37.3	18.0	17.4	24.2	33.3	19.6	21.9	24.9
De Morges Braun	24.2	13.7	7.6	15.2	33.1	17.3	8.8	19.7
Kweik	15.2	7.6	6.0	9.6	42.0	18.1	11.9	24.0
New Red Fire	21.4	14.2	16.2	17.3	38.4	22.0	31.5	30.6
Oakleaf Redder Ruffled	28.4	22.6	18.2	23.1	35.6	24.2	18.1	26.0
Oaky Red Splash	34.4	20.2	19.6	24.7	34.1	19.6	20.7	24.8
Outredgeous	25.6	12.2	15.6	17.8	27.8	12.6	15.8	18.7
Reine Des' Glaces	20.0	14.0	20.4	18.1	33.1	23.8	23.1	26.7
Romaine Dark Green	30.3	15.5	12.8	19.5	36.4	18.4	23.3	26.0
Sanquine Ameliore	25.0	15.8	14.6	18.5	24.2	15.7	13.9	17.9
Simpson Elite	24.6	17.8	15.2	19.2	36.0	23.1	22.4	27.2
Tom Thumb	11.1	7.0	4.7	7.6	30.8	19.0	16.3	22.0
Trout's Back	28.2	18.6	14.0	20.3	37.0	25.5	26.4	29.6
Victoria	16.0	14.4	14.8	15.1	48.0	28.8	31.0	35.9
Winter Density	22.3	20.0	13.0	18.4	34.1	26.8	16.2	25.7
Yugoslavian Red	14.5	10.8	9.4	11.6	33.3	23.0	17.9	24.7
Overall Mean	24.2	15.8	14.7	18.2	34.5	21.1	20.1	25.2
P Value	0.0000	0.0082	0.0070		0.0008	0.5590	0.0111	
Column	A	B	C		A	B	C	
Comparison	AvsB	BvsC	AvsC		AvsB	BvsC	AvsC	
Comparative P value	0.0000	0.1024	0.0000		0.0000	0.3386	0.0000	

**Table 3.** Size and marketability of 23 lettuce varieties grown in a hoophouse and a cloche with or without compost at WSU Vancouver REU and harvested weekly from November 18 through December 16.

	Obs. Dates -	18-Nov		24-Nov		01-Dec		08-Dec		16-Dec	
Variety	Treatment	Size	Mrk	Size	Mrk	Size	Mrk	Size	Mrk	Size	Mrk
Austrian Greenleaf	Hoophouse w/ C	L	M	L	M	L	M	M	M	L	M
Austrian Greenleaf	Cloche w/ C	S	NM	S	NM	S	NM	S	NM	S	NM
Austrian Greenleaf	Cloche w/o C	VS	NM	M	NM	S	NM	S	NM		
Bijou	Hoophouse w/ C	M	NM	M	NM	S/M	NM	M	NM	S	NM
Bijou	Cloche w/ C	VS	NM	S	NM	S	NM	S	NM		
Bijou	Cloche w/o C	L	NM	M	NM	S	NM	M	NM		
Blushed Butter Oak	Hoophouse w/ C	L	M	M	M	M/L	M	M	NM	S	NM
Blushed Butter Oak	Cloche w/ C	S	NM	S	NM	S	NM	M	NM	S	NM
Blushed Butter Oak	Cloche w/o C	VS	NM	S	NM	S	NM	VS	NM		
Bronze Arrowhead	Hoophouse w/ C	L	M	L	M	L	M	M	M	M	M
Bronze Arrowhead	Cloche w/ C	M	NM	M	M	M	NM	M	M	M	NM
Bronze Arrowhead	Cloche w/o C	S	NM	S	NM	M	NM	M	NM		
Brown Golding	Hoophouse w/ C	S	NM	M	NM	M	NM	S	NM	S	NM
Brown Golding	Cloche w/ C					S	NM	S	NM	S	NM
Brown Golding	Cloche w/o C			S	NM	S	NM	VS	NM		
Brunia	Hoophouse w/ C	L	M	L	M	L	M	L	M	M	M
Brunia	Cloche w/ C	VS	NM	M	M	S/M	NM	S	NM		
Brunia	Cloche w/o C	M	NM	S	NM	M	NM	S/M	NM		
Cardinale	Hoophouse w/ C	L	M	S	NM	L	M	L	M	M	M
Cardinale	Cloche w/ C	S	NM	S	NM	S	NM	VS	NM		
Cardinale	Cloche w/o C	S	NM	VS	NM	S	NM	S	NM		
Cracoviensis	Hoophouse w/ C	L	M	L	M	L	M	L	M		
Cracoviensis	Cloche w/ C	M	NM	M	NM	M	M	S	NM		
Cracoviensis	Cloche w/o C	M	NM	S	NM	M	M	M	NM		
De Morges Braun	Hoophouse w/ C	L	M	M	M	M/L	M	M	NM	L	M
De Morges Braun	Cloche w/ C					VS	NM				
De Morges Braun	Cloche w/o C			S	NM	VS	NM				
Kweik	Hoophouse w/ C	L	M	L	M	L	M	L	M	M	M
Kweik	Cloche w/ C	S	NM	M	M	S	NM			M	M
Kweik	Cloche w/o C	VS	NM			S	NM				
New Red Fire	Hoophouse w/ C	L	M	L	M	L	M	L	M	L	M
New Red Fire	Cloche w/ C	VS	NM	S	NM	S/M	NM	S	NM	M	NM
New Red Fire	Cloche w/o C	S	NM	M	M	M	NM	M	M		
Oakleaf Redder Ruffled	Hoophouse w/ C	L	M	L	M	L	M	L	M	M	M
Oakleaf Redder Ruffled	Cloche w/ C	S	NM	M	NM	M	NM	M	NM		
Oakleaf Redder Ruffled	Cloche w/o C	VS	NM	S	NM	S	NM				
Oaky Red Splash	Hoophouse w/ C	L	NM	L	M	L	M	L	M	L	M
Oaky Red Splash	Cloche w/ C	S	NM	S	NM	M	NM	S	NM	S	NM
Oaky Red Splash	Cloche w/o C	S	NM	VS	NM	S	NM	S	NM		

**Table 3. (Continued)**

Variety	Obs. Dates - Treatment	18-Nov		24-Nov		01-Dec		08-Dec		16-Dec	
		Size	Mrk	Size	Mrk	Size	Mrk	Size	Mrk	Size	Mrk
Outredgeous	Hoophouse w/ C	L	NM	M	NM	M	NM	M	NM	M	M
Outredgeous	Cloche w/ C	S	NM	S	NM	S/M	NM			S	NM
Outredgeous	Cloche w/o C	S	NM	VS	NM	S/M	NM	VS	NM		
Reine Des' Glaces	Hoophouse w/ C	L	M	M	M	L	M	L	M	M	M
Reine Des' Glaces	Cloche w/ C	S	NM	S	NM	S	NM	S	NM	S	NM
Reine Des' Glaces	Cloche w/o C	VS	NM	M	NM	S	NM	VS	NM		
Romaine Dark Green	Hoophouse w/ C	L	M	M/L	M	L	M	L	M	M	M
Romaine Dark Green	Cloche w/ C	S	NM	S	NM	S	NM			M	M
Romaine Dark Green	Cloche w/o C	VS	NM	S	NM	M	NM	S	NM		
Sanquine Ameliore	Hoophouse w/ C	L	NM	M	NM	S	NM	M	M	S	NM
Sanquine Ameliore	Cloche w/ C	S	NM	S	NM	S	NM	M	M		
Sanquine Ameliore	Cloche w/o C	VS	NM	S	NM	S	NM	VS	NM		
Simpson Elite	Hoophouse w/ C	L	NM	L	M	L	M	L	M	M	M
Simpson Elite	Cloche w/ C	VS	NM	M	NM	S	NM	S	NM	M	NM
Simpson Elite	Cloche w/o C	S	NM	S	NM	S	NM	VS	NM		
Tom Thumb	Hoophouse w/ C	S		S	M	S	M	M	M	S	NM
Tom Thumb	Cloche w/ C					S	NM			S	NM
Tom Thumb	Cloche w/o C					S	NM				
Trout's Back	Hoophouse w/ C	L	NM	L	M	M	M	L	M	L	M
Trout's Back	Cloche w/ C	S	NM	S	NM	S	NM	S	NM	S	NM
Trout's Back	Cloche w/o C	S	NM	S	NM	S	NM	S	NM		
Victoria	Hoophouse w/ C	L	NM	L	M	L	M	M	M	M	M
Victoria	Cloche w/ C	VS	NM	S	NM	M	NM	VS	NM	S	NM
Victoria	Cloche w/o C	S	NM	S	NM	M	M	S	NM		
Winter Density	Hoophouse w/ C	L	M	M	M	M	M	ML	M	M	M
Winter Density	Cloche w/ C	VS	NM	S	NM	S	NM	S	NM	S	NM
Winter Density	Cloche w/o C	M	NM	S	NM	S	NM	S	NM		
Yugoslavian Red	Hoophouse w/ C	L	M	M	M	L	M	M	NM		
Yugoslavian Red	Cloche w/ C	S	NM	S	NM	S	NM	S	NM		
Yugoslavian Red	Cloche w/o C	VS	NM	S	NM	M	NM	S	NM		

**Size**

S = Small

VS = Very Small

M = Medium

L = Large

**Marketability**

M = Marketable

NM = Non-Marketable

**Table 4.** Flavor ratings of 23 lettuce varieties grown in a hoop house and cloche and harvested from November 18 through December 16 at WSU Vancouver REU.

	<b>Hoophouse</b>	<b>Cloche</b>	
<b>Variety</b>	<b>w/ C</b>	<b>w/ C</b>	<b>Average</b>
Austrian Greenleaf	2.4	2.8	2.6
Bijou	2.2	3.3	2.7
Blushed Butter Oak	4.0	3.6	3.8
Bronze Arrowhead	2.6	3.4	3.0
Brown Golding	4.0	4.0	4.0
Brunia	1.8	3.3	2.5
Cardinale	3.8	3.0	3.4
Cracoviensis	3.8	2.8	3.3
De Morges Braun	3.6	3.0	3.3
Kweik	3.4	3.8	3.6
New Red Fire	3.6	2.4	3.0
Oakleaf Redder Ruffled	4.2	3.8	4.0
Oaky Red Splash	3.6	3.6	3.6
Outredgeous	3.2	2.3	2.7
Reine Des' Glaces	3.8	3.2	3.5
Romaine Dark Green	3.6	3.8	3.7
Sanquine Ameliore	3.8	3.8	3.8
Simpson Elite	3.4	3.2	3.3
Tom Thumb	2.6	4.5	3.6
Trout's Back	3.6	3.2	3.4
Victoria	3.8	3.2	3.5
Winter Density	4.4	4.4	4.4
Yugoslavian Red	3.8	3.8	3.8
Overall Mean	3.4	3.4	3.4
P Value	0.0002	0.2671	
Comparative P Value	0.8335		

**Flavor Rating**

Bitter = 1

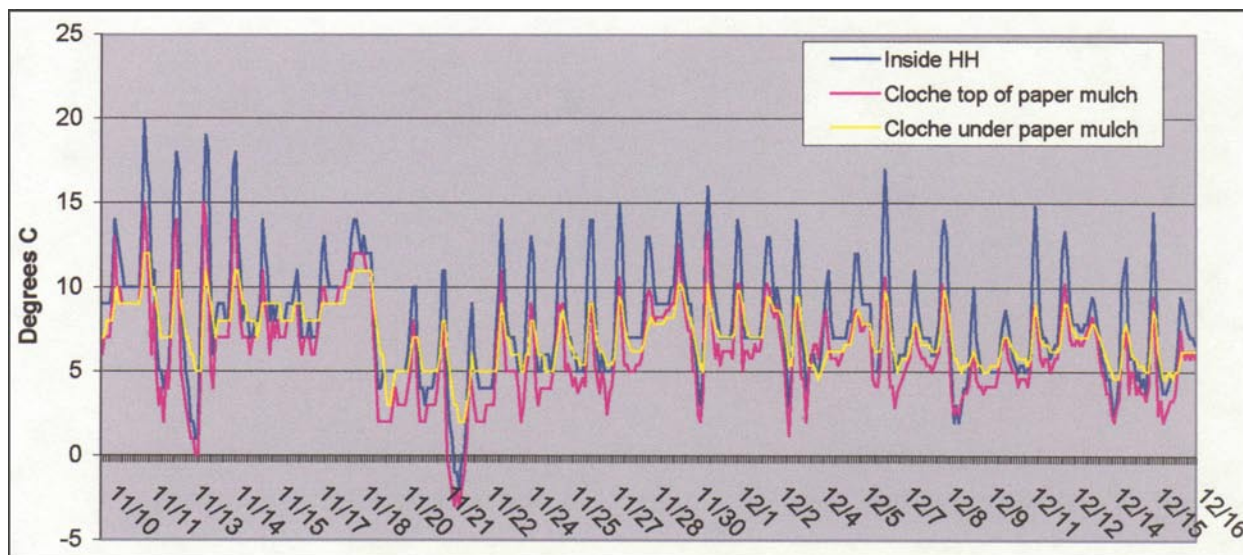
Slightly bitter = 2

Ok = 3

Good = 4

Very Good = 5





**Figure 1.** Temperatures (°C) measured at the soil surface inside the hoophouse and in the cloche on top and under the paper mulch from November 10 through December 15 2003 at WSU VREU.

**Table 5.** NO<sub>3</sub>-nitrogen (lbs/acre) measured in the field with and without compost once a week from October 16 to November 19.

	Oct. 13	Oct. 20	Oct. 27	Nov. 3	Nov. 10	Nov. 17
<b>With compost</b>	18	108	15	17	31	11
<b>Without compost</b>	15	31	15	15	11	7