

Impact of varieties and production methods on yield and vitamin C content in winter lettuce produced under greenhouse conditions

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Abstract: This paper describes the effects of different varieties and production methods on yield and vitamin C content in lettuce leaves produced in the winter period. A three-year study was conducted in a randomized block design under greenhouse conditions without additional heating. The trial included three varieties of lettuce ('Archimeds RZ', 'RZ Santoro', 'Kibo RZ'). Each row planted with these varieties was exposed to the following covering treatments: control treatment on bare soil, pre-sowing mulching with PE-black foil, post-planting covering with agro textile (17 grams), a combination of mulching + agro textile. The results show that the different methods of production affected the yield of lettuce. The highest yield was recorded in the agro textile treatment (14 kg/10m²), and the lowest in the control (9.31 kg/10m²). Throughout the three years of the trial, it was continuously evidenced that 'Santoro' had the biggest heads and the highest yield (15.33 kg/10m²), suggesting that the yield of lettuce is a varietal characteristics. Vitamin C content was found to differ, depending on the method of production, i.e. on the covering treatment applied. In average, the mulching + agro textile combination (26.77 mg/100 g) had the highest content while the control treatment had a significantly lower vitamin C content (21.10 mg/100 g).

Key words: lettuce, variety, vitamin C, production in winter conditions, yield.

Introduction

Recently, lettuce has been offered in green markets for a slightly longer period throughout the year. According to researches (Lazić et al. 2001; Mišković et al. 2001), lettuce is particularly important in the diet due to its high content of micronutrients such as copper, zinc, iron and magnesium, especially in the spring and autumn, the periods of the highest demand for this vegetable crop.

The abundance of different types and varieties of lettuce and its affiliation with yellow-green-red vegetables provides human nutrition with a very significant and high content of biologically important active substances (mineral substances, vitamins and organic substances) as well as coloured substances ranging from chlorophyll to anthocyanin (Aćamović-Đoković et al. 2011).

The cited authors state that lettuce is not rich in vitamin C, however, its advantage is that it is consumed fresh, with vitamin C being fully utilized, most notably in terms of the fact that this vitamin is heat labile and, hence, largely lost during the thermal processing of vegetables and fruits. Vitamin C plays multiple roles in the human organism. This vitamin increases resistance to viruses and bacterial infections including allergies. Pavlovic et al. (2011) emphasized that the role of vitamins and minerals in human health has been clearly established. Apart from this, vitamin C has marked antioxidant characteristics and is one of major antioxidant agents (Foyer 1993; Padayatty et al. 2003) in removing free radicals along with vitamins E and A, and the minerals selenium and zinc. Much of the current interest in vitamin C is focused on its ability, as a reducing agent, to quench free radicals. All of these effects may promote optimal health through support for the immune system and defense of tissues against the oxidative challenges associated with chronic disease, including cardiovascular disease and cancer (Frei 1991; Niki 1991; Stadtman 1991; Sevanian et al. 1991; Sies and Stahl 1995).

Material and methods

A three-year study was conducted in a randomized block design under greenhouse conditions without additional heating. The trial included three varieties of lettuce ('Archimeds RZ', 'RZ Santoro', 'Kibo RZ'). Each row planted with these varieties was exposed to the following covering treatments: control treatment on bare soil, pre-sowing mulching with PE-black foil, post-planting covering with agro textile (17 grams), a combination of mulching + agro textile.

Results and Discussion

The graph of daily temperatures (Figure 1) shows that the first two experimental years i.e. 2009 and 2010 had similar and favorable climatic conditions compared to 2011, which was a cold year. Maximum daily temperatures in 2009 and 2010 reached more than 25°C , which resulted in the rapid flow of vital processes in the lettuce. In the first two experimental years, no frost occurrence was observed. Daily maximum T in 2011 reached 22°C , while minimum T went up to -2°C , leading to a reduction in lettuce yield. Temperatures in the greenhouse were directly dependent on T in the open field, since the greenhouse was not heated. During hot weather, the temperature difference was 7.64°C , while during the cold days the temperature was in the range of 2.98 - 3.82°C . On the other hand, the use of different coverage methods affected the temperature disparity between the studied treatments in the experimental facility. Ponjičan (2004) observed a temperature difference due to the use of different materials for soil mulching and plant coverage in the range from 6.22°C to 12.71°C .

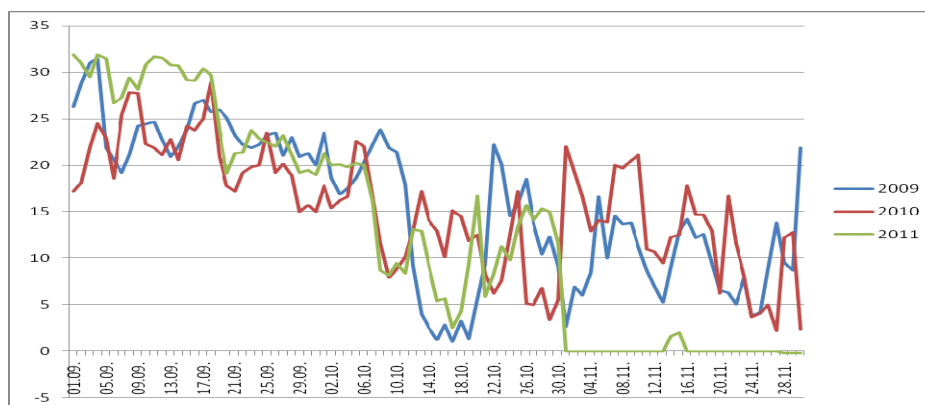


Figure1. The mean daily temperatures for the experimental production of lettuce

When comparing average yields under the different covering treatments, the mulching + agro textile combination was found to be the best option, leading to the maximum average yield of $13.33 \text{ kg per experimental plot i.e. } 55.5 \text{ kg}/10\text{m}^2$. The yield in this treatment was 58.50% higher compared to the control. Statistically, differences in the values of this covering treatment compared to the first, second and third treatments are observed at $P < 0.01$.

The results on the effect of variety on average lettuce yield indicate differences among the varieties. Actually, the yields ranged from 30.4 to $55.6 \text{ kg}/10\text{m}^2$.

In 2010, higher average yields were obtained compared to the previous year. The covering treatments resulted in a significant increase in lettuce yield. The plants on agro textile had maximal productivity (19.27 kg) i.e. 80.2 kg/10m². The yield in this treatment was 71.13% higher compared to the control.

The differences in the average yield of the third treatment are estimated at the significance level of $P < 0.01$ in relation to the first and the second treatments, and at $P < 0.05$ compared to the fourth treatment (Table 1).

Depending on the choice of variety, yields ranged from 46.8 to 80.5 kg/10m². Variations in the value of the average yield of 'Santoro' (19.32 kg) compared to 'Archimedes' (11.24 kg) and 'Kibou' (14.08 kg) were evaluated at the threshold of significance of 1 %.

The differences in the average yield of the fourth treatment (4.56 kg) compared to the first (2.70 kg) and the second treatment (3.19 kg) were at the level of significance of $P < 0.01$. In A1 treatment, the yield was 40.79% lower than in A4 treatment; in A2 and A3, it was lower by 30.05 % and 5.93%, respectively, than in A4. Nguyen et al. (2006) achieved similar results in their trial. In the final year, lower yield values were observed compared to the previous two years. Yield was reduced due to low temperatures and occasional temperature declines below 0°C (Figure 1) which affected the growth of lettuce. The results of these studies are completely consistent with the results of recent research (Kosović 1989), which reported the negative impact of low temperatures on the growth and yield of lettuce.

Table 1. The average yield at the experimental plots (kg)

	Cover	'Archimedes'	'Santoro'	'Kibou'	$\bar{X}$
2009	control	7.30	8.95	9.00	8.41
	black PE foil	7.60	14.20	12.39	11.39
	agrotextile	6.90	11.25	11.30	9.81
	black PE foil + agrotextile	7.40	19.00	13.60	13.33
	$\bar{X}$	7.30	13.35	11.57	10.79
2010	control	8.77	15.34	9.66	11.26
	black PE foil	12.14	18.35	11.21	13.90
	agrotextile	13.72	24.95	19.14	19.27
	black PE foil + agrotextile	10.33	18.66	16.29	15.10
	$\bar{X}$	11.24	19.32	14.08	14.88
2011	control	2.52	2.85	2.73	2.70
	black PE foil	2.77	3.71	3.09	3.19
	agrotextile	3.51	5.25	4.09	4.29
	black PE foil +	3.78	4.88	5.02	4.56

agrotextile									
	$\bar{X}$								
	3.14			4.17			3.73		
	3.68								
LSD	2009			2010			2011		
	A	B	AXB	A	B	AXB	A	B	AXB
0.05	0.98	0.86	1.73	3.25	2.82	5.65	0.48	0.41	0.83
0.01	1.32	1.16	2.32	4.34	3.78	7.56	0.64	0.55	1.11

Over the three-year period, it was continuously confirmed that ‘Santoro’ had the biggest heads and the highest yield (15.33 kg/10m²). The results obtained in our trial are consistent with the research of a number of authors showing that lettuce yield depends primarily on variety, production conditions, nutrition, dates of seeding and picking (Brunsgard et al. 1994, Santamaria et.al 2001, Converse et al. 2004).

Vitamin C content

Vitamin C is an important factor in the human diet. Specifically, this vitamin is involved in various biological processes and is the strongest antioxidant among vitamins. Lettuce cultivars with a higher content of vitamin C and anthocyanins may be a good source of antioxidants, especially in winter, when there is a low intake of fresh vegetables.

Table 2. The vitamin C content in lettuce (mg/100 g)

Cover		Control	PE foil	Agro textile	PE+agrite	$\bar{X}$
‘Archimeds’	2009	10.06	11.14	12.72	13.33	11.81
	2010	28.30	34.40	35.30	35.80	33.45
	2011	26.23	26.05	29.67	32.19	28.53
‘Santoro’	2009	10.13	10.09	10.89	11.63	10.68
	2010	22.50	21.40	41.00	41.00	31.50
	2011	23.34	23.87	29.22	27.64	26.01
‘Kibou’	2009	10.23	13.16	13.20	13.27	12.46
	2010	38.70	36.80	31.20	42.30	37.25
	2011	20.49	30.65	29.79	23.75	26.17
$\bar{X}$		21.10	23.06	25.88	26.77	24.41

Vitamin C has the ability to reduce the creation of carcinogenic N-nitroso compounds (Tannenbaum et. al. 1991). The recommended daily vitamin C intake for men and women is 60 mg and 100 mg for pregnant women.

Vitamin C ranged from 10.06mg/100g to 42.30 mg/100g (Table 2). Values of vitamin C content depended on production method i.e. on the covering treatment

applied. On average, the mulching + agro textile combination (26.77 mg/100 g) gave the highest content, while the control treatment had a significantly lower content of C vitamin. The results of the present study are contrary to the data of Balalić (2004), who reported that the average vitamin C content was the highest in the treatment without mulching (8.07 mg/100 g), and lowest in mulching with black foil (7.8 mg/100 g).

The two-year average results on vitamin C content in lettuce showed that 'Santoro' had the lowest content (21.09 mg/100 g), and 'Kibou' the highest content of vitamin C (24.85 mg/100 g).

The presented data on the effect of variety on vitamin C content are consistent with the research of (Siomons 2002) where vitamin C content, depending on variety, ranged from 31.50 mg/100g to 37.25 mg/100g. Also, Llorach et al. (2008) and Petrikova and Pokluda (2003) observed that the content of vitamin C is affected by a number of factors, primarily variety.

Conclusion

The three-year studies showed that covering treatments significantly affected the yield of lettuce. The highest yield was recorded in agro textile treatment (14 kg/10m²), and the lowest in the control (9.31 kg/10m²).

Plants grown under different mulching treatments (PE foil, agro textile, agro textile + PE foil) achieved significant or highly significant differences in the parameters tested compared to plants grown on bare soil. The combined use of mulching + agro textile led to the highest yield in the trial in the first and the third year. In the second year, maximum yield was determined in the agro textile treatment. The lowest values for all test parameters were determined in the control treatment. Vitamin C content depended on the covering method and ranged from 21.10 mg/100g (bare soil) to 26.77 mg/100 g (a combination of mulching + agro textile).

Throughout the three years of the trial, it was continuously confirmed that 'Santoro' had the biggest heads and the highest yield (15.33 kg/10m²).

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UTICAJ SORTE I NAČINA PROIZVODNJE NA PRINOS I KVALITETNE OSOBINE SALATE PROIZVEDENE U ZIMSKIM USLOVIMA

- originalni naučni rad -

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Rezime

U radu je prikazan uticaj sorte i različitih načina proizvodnje na prinos i sadržaj vitamina C u listu salate proizvedene u zimskom periodu. Trogodišnja ispitivanja su obavljena putem slučajnog blok sistema u plasteniku bez dodatnog grejanja. U ogledu su bile zastupljene tri sorte salate (Archimeds RZ, Santoro RZ, Kibou RZ). Svaki red sorte je bio podvrgnut sledećim varijantama pokrivanja: kontrola-sadnja na nepokrivenom zemljištu; malčovanje pred sadnju sa PE-crnom folijom; agrotekstil-pokrivanje biljaka nakon sadnje agrotekstilom (17 grama); kombinacija malčovanje + agrotekstila.

Dobijeni rezultati pokazuju da su različiti načini proizvodnje uticali na prinos salate. Najveći prinos zabeležen je na agrotektilu ($14 \text{ kg}/10\text{m}^2$), a najmanji kod kontrole ($9,31 \text{ kg}/10\text{m}^2$). Kroz sve tri godine ogleda kontinuirano se potvrđuje da je sorta Santoro imala najkrupnije glavice kao i najveći prinos ($15,33 \text{ kg}/10\text{m}^2$). Ispitivanje sadržaja vitamina C pokazala su da se u zavisnosti od načina proizvodnje tj. primenjene varijante pokrivanja razlikuje. U proseku najveći sadržaj pokazala je kombinacija malčovanje + agrotekstila ($26,77 \text{ mg}/100\text{g}$), dok je kontrolna varijanta imala značajno manji sadržaj C vitamina ($21,10 \text{ mg}/100\text{g}$).

Ključne reči: salata, sorta, vitamin C, zimska proizvodnja, prinos.

