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THE INFLUENCE OF VARIETY AND FERTILIZATION ON THE YIELD AND CONTENT OF VITAMIN C IN LEAF OF PARSLEY *(Petroselinum ssp.)*

SUMMARY

In this paper the impact of different varieties and fertilizers on yield and vitamin C content in the leaf of parsley was investigated. In two-year research, three varieties of parsley were used and three variant of fertilization were applied (mineral fertilizers, organic and organomineral fertilizer) as well as control variant. The varieties used in the research are: „Domestic sawmills “, „Berlin semi-long type “, „Mooskrause “. The yield of leaf and vitamin C content of the leaf parsley was significantly influenced by the variety and type of fertilizer. In both years the research the highest yield of leaf was achieved by variety „Domestic sawmills “, with an average yield of 58.69 t/ha, while the highest vitamin C content had a variety „Berlin semi-long “. Two – year research showed that the application of organic fertilizer had a positive effect on yield and vitamin C content in leaf of parsley.

Key words: leaf of parsley, variety, fertilizers, yield, vitamin C.

INTRODUCTION

Parsley (*Petroselinum hortense*) is important vegetable, aromatic and medicinal plant origin in the Mediterranean area. It is growing because of its turnip root and leaves of characteristics, pleasant smell and taste. Both fresh and dried parsley are used in food, cosmetic and pharmaceutical industry, for production of spices, essential oil and medication production as well (Lopez et al. 1999). The production of parsley in BiH is not sufficiently represented and most of our parsley production is in households. Although the climatic conditions for cultivation are favorable, there is no more intensive production, and there is no

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use of modern technology in cultivation, while at the same time import is noticeable.

The growing conditions, including soil type, fertilization, moisture content and insolation, may have had influence on yield and biological value of parsley leaf **(**Jadczak *et al*. 2018). Very important for productivity and quality of parsley is correct selection genotype in certain production conditions. There are three types of parsley: flat leaves parsley (*ssp. neapolitanum*); curly leaves parsley (*ssp. crispum*) which are planted because of their leaves and there is also turnip rooted parsley (*ssp. tuberosum*) that is planted because of its root. Types of parsley differ in morphology and chemical composition, but also in essential oil content and composition (Petropoulus *et al*. 2004).

Vitamin C is an important factor in human nutrition. Although there are many functions of vitamin C, his role in health is discussed mostly in relation to its role as an antioxidant and its effects on cancer, blood pressure, immunity, drug metabolism and urinary excretion of hydroxyproline (Barrita and Sanchez 2013). One is of the most important factor in the nutritional quality many horticultural crops and has many biological activities in human body.

Parsley leaves contain from 96.88 to 312.7 mg / 100 g of vitamin C, far exceeding its content in lemon and orange (Osinska *et al*. 2012). The same authors was found that the content of vitamin C in frozen parsley leaves ranges from 10.06 to 47.10 mg / 100 g.

According to the results of the research carried out by Cauni *et al*. (2010), the leafy parsley contains significantly more vitamin C (133.0 mg/100 g) with compared some other leafy vegetables (celery 85.0 mg/ 100 g, lettuce 24.0 mg/100 g, cabbage 51.0 mg/100 g).

The aim of the research was to determine how the variety and type of fertilizer effects on yield and the content of vitamin C in the leaf of parsley.

MATERIAL AND METHODS

Research of the yield and content of vitamin C in leaves of parsley during two vegetation periods: 2013 and 2014 was done. We perfomed two factorial field experiment in area in the north suburb of Mostar, called Bijelo Polje. We set this in randomized block in 4 replications, the whole parcel was 1 m^2.

Three parsley varieties were used as the subject of the research and three fertilization variants plus a control variant were applied.

The varieties used in the research are: Domestic sawmills "- sawmill type (*P. hortense* ssp. *neapolitanum*), „Berlin semi-long "- root type (*P. hortense* ssp. *Tuberosum*), „Mooskrause "- curlyleaves type (*P. hortense* ssp.*crispum*).

Variants of fertilization are: organic, organo-mineral, mineral and control variant. All types of fertilizers were applied with pre-sowing soil preparation.

For organic fertilization sheep manure was used, in an amount of 20 t/ha. Sheep manure on average contains 0.60% N, 0.3% P_2O_5 and 0.2% K_2O (Lazić *et al*. 2013). The organic matter content is about 29%. As an organomineral fertilizer, we used Phenix fertilizer. It is a combination of organic and mineral

fertilizers whose NPK values are 6: 8: 15 + MgO. The percentage of organic matter is 50%. Organo-mineral fertilizer was applied in the recommended amount for vegetable crops of 1 t/ha. For mineral fertilization, a permanently complex fertilizer NPK 8:16:24 was applied in a quantity of 720 kg/ha and KAN (27% N) fertilizer in an amount of 170 kg/ha to supplement the required quantity N. Quantities of applied fertilizers were within the ranges recommended by different authors (Lešić *et al*. 2004, Lazić *et al.* 2013).

The seed was sown in rows at a distance of 20 cm, in the first decade of March. The rate of sowing is 3 g/m^2.

Before setting up the experiments, soil samples were taken for chemical analysis, from the 0-30 cm depth. The results of the analysis showed that the pH value of the soil determined in water has a slight alkaline reaction (7.56) and in KCl poorly acidic to neutral (6.76). The total N (Kjeldahl) content was 0.21 percent indicating that the soil was well supplied with nitrogen. According to the content of available P_2O_5 (8.20 mg/100 g), determined by the Al-method according to Egner-Riehm, the soil is poorly supplied with phosphorus (class III). The content of K_2O (Al-method according to Egner-Riehm) was 16.80 mg/100 g, which corresponds to a good supply (class II) The content of humus is 1,60 percent, which indicates that the soil has low humus content.

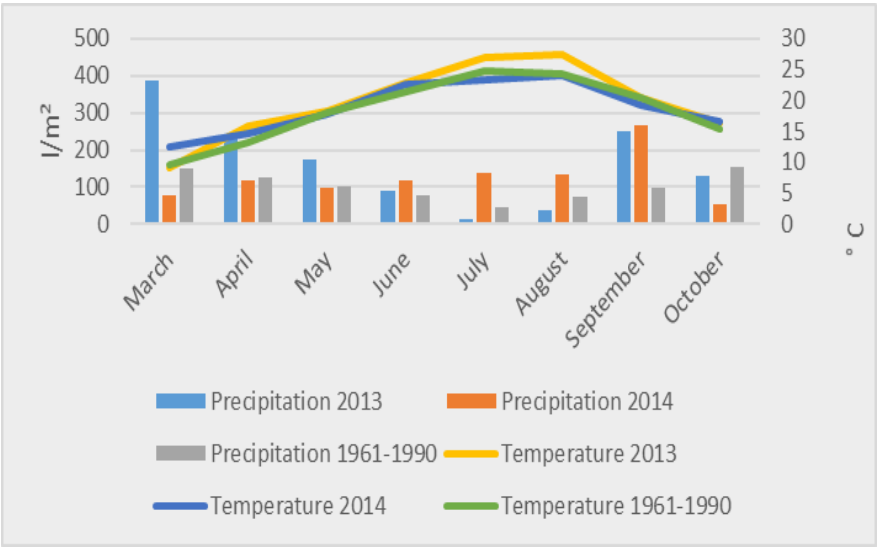
The yield of the leaves (t/ha) was determined by measuring the overhead part of the plant after each cutting (three cuttings), on the basis of that we obtained the yield by the cuttings and the total yield. The first cutting was in the second decade of June, the second in the first decade of September and the third in the last decade of October. The results presented data for the total yield.

Samples for the analysis of plant material were taken after the first cuttings of the leaf. After taking the samples were frozen at -18 ˚C for one month. The content of vitamin C was determined by titration using iodide solution (Skroza *et al*. 2010).

Presented data are statistically processed using the software package program SPSS 20. Two-way ANOVA followed by post hoc Tukey's test for mean separation was performed and the significant differences (p=0.05) were determined. This method was used in order to investigate the influence of interaction of two examined factors (independent variables), fertilizers and genotypes, on the dependent variables, yield and content of vitamin C. Pearson's Correlaton was done in order to measure the strength and direction of linear relationships between pairs of continuous variables.

Climatic factors

During the experiment, the climatic conditions of the area where the experiment was set up were monitored. The data of the Federal Meteorological Institute in Sarajevo, Mostar meteorological station, were used for the analysis of climatic conditions. Graph 1 shows the average air temperatures and precipitation during the growing season in both years of the research, as well as the perennial averages for average air temperatures and precipitation.



Graph 1. Average air temperatures and precipitation during the growing seasons 2013-2014 and perennial averages in the Mostar area

RESULTS AND DISCUSSION

The yield of leaf parsley, depending on variety and used fertilizer variant as well, was from 21.68 to 80.30 t/ha.

Table 1. The Influence of variety and fertilization on yield of parsley leaf (t/ha) in 2013.

Fertilizer	Genotyp			**Average**
	"Domestic sawmills"	„Berlin semi long"	„Mooskrause“	$\bar{x}$ ± SD
Control	61,51	36,40	33,81	**43,91**^{A} ± 3,03
Organic	80,30	46,31	55,45	**60,69**^{B} ± 3.03
Organo-mineral	46,85	29,02	30,44	**35,44**^{C} ± 3,03
Mineral	60,00	33,83	35,40	**43,10**^{AC} ± 3.03
Average	**62,16**^{a}	**36,43**^{b}	**38,77**^{c}	
		Sig.		
Genotype		,000		
Fertilizer		,000		
Genotype*Fertilizer		,388		

^{a,b,c} *– significant differences between genotypes themselves (p<0.05)*
$^{A, B, C}$ *– significant differences between examined fertilizers (p<0.05)*

From data presented in Table 1 can be seen that there is no statistically significant interaction between the effect of variety and fertilizer on parsley yield in 2013 (p=.388), but there is statistically significant difference between varieties

themselves ($p<0.05$). Nevertheless, can be concluded that the yield obtained with organic fertilizer is significant different compared to other examined fertilizers ($p<0.05$).

Table 2. The Influence of variety and fertilization on yield of parsley leaf (t/ha) in 2014.

Fertilizer	Genotyp			**Average**
	"Domestic sawmills"	„Berlin semi long"	„Mooskrause“	$\bar{x}$ ± SD
Control	50,22	26,17	21,68	**32,69**^{A} ± 3,14
Organic	56,51	38,56	24,28	**39,78**^{AB} ± 3.14
Organo-mineral	43,48	24,84	21,72	**30,00**^{C} ± 3,14
Mineral	70,73	27,79	29,53	**42,68**^{B} ± 3.14
Average	**55,23**^{a}	**29,34**^{b}	**24,30**^{c}	
		Sig.		
Genotype		,000		
Fertilizer		,001		
Genotype*Fertilizer		,034		

^{a,b,c} *– significant differences between genotypes themselves ($p<0.05$)*
$^{A, B, C}$ *– significant differences between examined fertilizers ($p<0.05$)*

From data presented in Table 2 can be seen that there is statistically significant interaction between the effect of variety and fertilizer on parsley yield in 2014 ($p=.034$). So, there is statistically significant difference between all of the examined varieties and fertilizers themselves ($p<0.05$). On the other hand, from post hoc tests, can be concluded that the parsley treated with organo-mineral fertilizer has significant difference yield ($p<0.05$) compared to yields obtained with other examined fertilizers.

In both years of research, the highest yield of parsley leaves had variety „Domestic sawmills “. Leafy parsley had higher yield of overhead biomass, and it had more leaves than petals when we compared it with root parsley Kmiecik and Lisiewska (1999). Research results Jadczak *et al*. (2018) showed that the yield of parsley leaves varied significantly between different varieties and years of research and ranged from 57.40 to 166.52 t/ha. According to research Kolota (2011) flat leaf parsley, to which the variety „Domestic sawmills“belongs, depending on fertilization with different amounts of nitrogen, had lower yield of leaves when we compared it with curly parsley, to which the variety „Mooskrause“ belongs. These authors obtained that the yield of the curly parsley type ranged from 55.3 to 60.9 t/ha and flat leafy parsley from 52.5 to 59.6 t/ha.

In terms of fertilization, the lowest leaf yield in both years of the our research was achieved with the use of organo-mineral fertilizer. In 2013, the highest yield of parsley leaves was with the usage of organic fertilizer, and it was significantly higher when we compared it with other variants of fertilizer. In

2014, the highest yield was achieved by application of mineral fertilizer, but the usage of mineral fertilizer was not significant when compared it with the application of organic fertilizer. Lim and Vimala (2012) say that the usage of appropriate amount of organic fertilization of leafy vegetable can give the same yields or even higher yields when we compare it with vegetable fertilized with mineral variant of fertilizer.

The fact that optimal yield of parsley leaves can be achieved with the use of organic fertilizer is significant, since parsley belongs to a group of leafy vegetables that has a tendency to increase the accumulation of harmful nitrates, especially in conditions of inadequate mineral fertilization and excessive use of nitrogen fertilizers (Santamaria 2006). Rahimić *et al*. (2018) found that both leaf and root of parsley accumulated significantly more nitrate with the use of mineral fertilizer compared to organic and organomineral fertilizer, as well as variant without the use of fertilizers. The usage of organic fertilizer (manure) had positive influence and its increased growth and carrot's root yield (Ahmed *et al.* 2014.).

All three parsley varieties had significantly higher leaf yield in 2013, when we compared it with the yield in 2014. This difference may be conditioned by the weather conditions, due to the weather conditions differ between years of research (Graph 1). There was a lot of rainfal during the spring and the summer in 2014. There were also a lot of cloudy days during growing period in 2014, and parsley is a plant that requires a lot of light.

The content of vitamin C in the leaf of parsley, depending on investigated factors, was from 24.00 to 64.67 mg/100 g. As we have already said in material and methods of our work, plant material was frozen for one month before we used it for chemical research. The content of vitamin C in the leaf of curly parsley was from 222.0 to 299.7 mg/100 g, and the content of vitamin C in leafy parsley was from 196.4 to 285.6 mg/100 g (Kolota 2011). In our research, we have found lower values of the content of vitamin C, the reason for that is because our researched plant material was frozen.

According to data presented in Table 3 can be seen that there is no statistically significant interaction between the effect of variety and fertilizer on the content of vitamin C in parsley in 2013 ($p=.481$). There is no statistically significant differences, neither between the examined varieties, nor between examined fertilizers themselves ($p>0.05$).

According to data presented in Table 4 can be seen that there is statistically significant interaction between the effect of variety and fertilizer on the content of vitamin C in parsley in 2014 ($p=.000$). In this case, there is significant differences between all of the examined varieties and fertilizers themselves, too ($p<0.05$). From post hoc tests, can be concluded that the vitamin C in the parsley treated with organic-mineral fertilizer is significant different ($p<0.05$) compared control variant.

Table 3. The Influence of genotype and fertilization on on the vitamin C content in the leaf of parsley (mg/100 g) in 2013.

Fertilizer	Genotyp			**Average**
	"Domestic sawmills"	„Berlin semi long"	„Mooskrause“	$\bar{x}$ ± SD
Control	47,82	48,67	53,47	**49,99**^{A} ± 6.51
Organic	44,33	57,46	39,00	**46,93**^{A} ± 6.51
Organo-mineral	31,00	37,33	35,00	**34,44**^{A} ± 6.51
Mineral	45,52	34,45	24,00	**34,66**^{A} ± 6.51
Average	**42,17**^{a}	**44,48**^{a}	**37,88**^{a}	
		Sig.		
Genotype		,503		
Fertilizer		,045		
Genotype*Fertilizer		,481		

^{a} – *no significant differences between genotypes themselves (p>0.05)*
^{A} – *no significant differences between examined fertilizers (p>0.05)*

Table 4. The Influence of variety and fertilization on the vitamin C content in the leaf of parsley (mg/100 g) in 2014.

Fertilizer	Genotyp			**Average**
	"Domestic sawmills"	„Berlin semi long"	„Mooskrause“	$\bar{x}$ ± SD
Control	37,03	39,33	24,50	**33,62**^{A} ± 3,14
Organic	33,70	35,33	59,67	**42,90**^{AB} ± 3.14
Organo-mineral	26,87	64,67	41,83	**44,46**^{B} ± 3,14
Mineral	51,40	45,00	34,40	**43,60**^{AB} ± 3.14
Average	**37,25**^{a}	**46,08**^{b}	**40,10**^{c}	
		Sig.		
Genotype		,036		
Fertilizer		,028		
Genotype*Fertilizer		,000		

^{a,b,c} – *significant differences between genotypes themselves (p<0.05)*
$^{A, B,}$ – *significant differences between examined fertilizers (p<0.05)*

In both years of our research, the highest content of vitamin C in the leaf of parsley had the variety „Berlin semi-long “. Our results were the same as results of Kmiecik and Lisiewska research (1999), and their research showed that all genotypes of leafy parsley had lower content of vitamin C when compared it with root parsley. The similar results were in Valšikova research *et al.* (2016). In their research, the content of vitamin C in the leaf of parsley was significantly different, depending on the variety, and significantly higher content of vitamin C had variety of root parsley, when we compared it with variety of leafy and curly parsley.

The fertilization of parsley with different type of fertilizer did not have positive influence on the content of vitamin C in the leaf in 2013, because the highest content had the leaf of parsley in controlled variant. However, these differences were not statistically significant. When we compared it with previous years, the lowest content of vitamin C in 2014 was in control variant, significant lower with compare to organo-mineral variant, while compared to the other variants of this difference was not significant. The similar results were in Warman and Havard research (1997), they have researched the influence of organic and mineral fertilizer on the content of vitamin C in carrot and cabbage.

When we calculate the two-year average, we can conclude that the highest content of vitamin C was in organic variant of fertilization (44.91 mg/100 g), and the lowest content of vitamin C was in mineral variant of fertilization (39.13 mg/100 g).

Table 5. Correlation between the yield obtained with several fertilizers and varieties used in this research (two-year average)

		Control	Organic	Organo-mineral	Mineral	Domestic Sawmills	Berlin semi long	Mooskrause
Control	Pearson Correlation	1	,999*	,997*	,988	,070	(,132)	(,293)
	Sig. (2-tailed)		,022	,049	,101	,955	,916	,811
	N		3	3	3	3	3	3
Organic	Pearson Correlation		1	,999*	,992	,036	(,166)	(,326)
	Sig. (2-tailed)			,027	,079	,977	,894	,789
	N			3	3	3	3	3
Organo-mineral	Pearson Correlation			1	,997	(,006)	(,207)	(,365)
	Sig. (2-tailed)				,052	,996	,867	,762
	N				3	3	3	3
Mineral	Pearson Correlation				1	(,088)	(,286)	(,440)
	Sig. (2-tailed)					,944	,815	,710
	N					3	3	3
Domestic Sawmills	Pearson Correlation					1	,781	,883
	Sig. (2-tailed)						,219	,117
	N						4	4
Berlin semi long	Pearson Correlation						1	,940
	Sig. (2-tailed)							,060
	N							4
Mooskrause	Pearson Correlation							1
	Sig. (2-tailed)							
	N							

*. Correlation is significant at the 0.05 level (2-tailed).

In the research of Poubova (2003) about the influence of different variants of fertilization (organic fertilization, mineral fertilization (N) + organic, as nitrogen fertilization itself) on the yield and the content of vitamin C in the fruits of pepper, there was no difference in the content of vitamin C in different variants

of fertilization, while the content of vitamin C was the lowest in the variant without fertilization.

The results of other researches, the influence of fertilization variant on the content of vitamin C in vegetables, were different. The lowest content of vitamin C with the usage of organic fertilizer, when we compared it with mineral variant was found in Sikora research *et al.* (2010), while the Worthington research (2001) showed that the content of vitamin C in average was higher for 27% in vegetables fertilized with organic fertilizer, when we compared it with vegetable fertilized with mineral variant of fertilizer, the exception was with carrot. On the other hand, the research Fjelkner-Modig *et al.* (2000), the content of vitamin C in cabbage, onion, peas and potato was not significantly different in the usage of different variants of fertilizers (organic and mineral). The higher content of vitamin C was in the organic production of carrot and potato, that was found in the research of Hunter *et al*. (2011).

According to the results presented in Table 5, can be seen that there is strong possitive correlation between the parsley yield in untreated variant and variant treated with organic (r= +.999*) and organic-mineral fertilizer (r= +.997*) at level 0.05. On the other hand, there is strong possitive correlation between the analyzed organic and organic-mineral fertilizer (r= +.999*) at level 0.05.

CONCLUSIONS

The variety and the type of fertilization significantly affected on the yield of parsley leaves and the content of the vitamin C in the leaf of parsley. The variety „Domestic sawmills“had significantly higher yield in the leaves when we compared it with other varieties in both years of our research (55.23-62.16 t/ha).

The usage of organic fertilizer had the highest leaf yield in 2013 (60.69 t/ha), significantly it was higher when we compared it with controlled variant and other variants of fertilization, while it had the highest leaf yield with mineral variant of fertilization in 2014 (42.68 t/ha), but it wasn't significantly different from the yield in organic variant (39.78 t/ha). All three varieties had higher leaf yield in 2013 when we compared it with 2014.

In both years of our research the highest content of vitamin C had variety „Berlin semi-long”. In 2013 this content was not significantly different from other two varieties in our research, while it was significant in 2014.

According to two-year average, the highest content of vitamin C in the leaf of parsley was with the usage of organic fertilizer.

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