YIELD AND QUALITY OF CHICORY (CICHORIUM INTYBUS L.) IN DEPENDENCE ON VARIETY AND FOLIAR APPLICATION OF ATONIK AND POLYBOR 150

ÚRODA A KVALITA ČAKANKY (CICHORIUM INTYBUS L.) V ZÁVISLOSTI OD ODRODY A FOLIÁRNEJ APLIKÁCIE ATONIKU A POLYBORU 150

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ABSTRACT

The influence of variety and foliar applications of Atonik and Polybor 150 on root yield and inulin content in root of chicory (Cichorium Intybus L.) plant were observed in field polyfactorial experiment. The field trials were established on experimental station Dolná Malanta in warm maize production area in 2005 and 2006 years. The root yield and inulin content were statistically high significantly influenced by year's weather conditions. In term of obtained root yield and inulin content in root the combination of foliar preparations on variant B (Atonik: 0.4 l ha^{-1} in 2nd post-emergence herbicide application; Atonik + Polybor 150: 0.6 + 2.5 l ha^{-1} in 3rd post-emergence herbicide application; Polybor 150: 2.5 l ha^{-1} in 1st fungicide treatment) was shown to be optimal in given agri-ecological conditions. Biological material affected the formation of yield parameters very differently. The highest yield of root was observed at variety Fredonia Nova and inulin content in root at variety Maurane (both statistically significant).

Keywords: chicory, variety, Atonik, Polybor 150, yield, inulin

ABSTRACT IN SLOVAK LANGUAGE

V poľných polyfaktorových experimentoch bol sledovaný vplyv odrody a foliárnej aplikácie Atoniku a Polyboru 150 na úrodu koreňa a obsah inulínu v koreni čakanky. Poľný experiment bol uskutočnený v rokoch 2005 a 2006 na experimentálnej stanici Dolná Malanta v teplej kukuričnej výrobnej oblasti na stredne ťažkej hnedozemi. Poveternostné podmienkami stanovišťa ovplyvnili výšku úrody koreňa, ako aj obsah inulínu v koreni štatisticky vysoko preukazne. V daných agroekologických podmienkach bol vplyv termínu foliárnej aplikácie Atoniku a Polyboru 150 na úrodu koreňa a obsah inulínu v koreni najvýznamnejší v experimentálnom variante B (Atonik 0,4 l.ha^{-1} - druhá postemergentná aplikácia herbicídu; Atonik + Polybor 150: 0,6 + 2.5 l.ha^{-1} - tretia postemergentná aplikácia herbicídu; Polybor 150: 2,5 l.ha^{-1} - prvé fungicídne ošetrenie). Biologický materiál ovplyvňoval formovanie úrodových parametrov rozdielne. Vplyv odrody na úrodu koreňa bol štatisticky signifikantný. Najvyššia úroda bola zaznamenaná pri odrode Fredonia Nova a najvyšší obsah inulínu v koreni bol pri odrode Maurane.

Kľúčové slová: čakanka, odrody, Atonik, Polybor 150, úroda, inulín

DETAILED ABSTRACT IN SLOVAK LANGUAGE

V poľných polyfaktorových experimentoch, založených v agroekologických podmienkach teplej kukuričnej výrobnej oblasti na pozemkoch Strediska biológie a ekológie rastlín Dolná Malanta, bol sledovaný vplyv biologického materiálu a foliárnej aplikácie biologicky aktívnych látok a hnojív Atonik a Polybor 150 na úrodu koreňa a obsah inulínu v koreni čakanky obyčajnej (Cichorium intybus L.). Poľné experimenty boli uskutočnené v rokoch 2005 a 2006 na stredne ťažkej hnedozemi.

Experimenty boli založené blokovou metódou, s náhodným usporiadaním pokusných členov a s počtom opakovaní 3. Sledované boli 3 odrody čakanky (Oesia, Maurane, Fredonia Nova) a 3 varianty aplikácie biologicky aktívnych látok. Poveternostné podmienky záujmového územia boli zaznamenávané z Agrometerologickej stanice FZKI SPU v Nitre. Výsledky experimentu boli spracované prostredníctvom štatistického balíka Statgrafic a Office 2003.

Atonik je biologický rastový stimulátor (fi. ASAHI Chemicals MFG. CO., LtD. Japonsko) pozitívne pôsobiaci na priebeh biochemických a fyziologických procesov v rastline.

Polybor 150 je špeciálne vysoko koncentrované hnojivo určené pre doplnkovú výživu plodín s vyššími nárokmi na bór.

Predplodinou čakanky obyčajnej bola pšenica letná - forma ozimná (Triticum aestivum L.). Spôsob založenia porastu bol v súlade so zásadami technológie pestovania čakanky obyčajnej s minimálnym podielom ľudskej práce (podmietka, stredne hlboká orba, hlboká orba, kompaktor, výživa a hnojenie na plánovanú úrodu 30 $t.ha^{-1}$, mechanická kultivácia, zber) na vzdialenosť výsevu v riadku 115 mm.

Z dosiahnutých výsledkov vyplýva, že poveternostné podmienkami stanovišťa ovplyvnili výšku úrody koreňa, ako aj obsah inulínu v koreni štatisticky vysoko preukazne. V sledovaných agroekologických podmienkach bol vplyv termínu foliárnej aplikácie Atoniku a Polyboru 150 na úrodu koreňa obsah inulínu v koreni najvýznamnejší na experimentálnom variante B (Atonik 0,4 $l.ha^{-1}$ - druhá postemergentná aplikácia herbicídu; Atonik + Polybor 150: 0,6 + 2,5 $l.ha^{-1}$ - tretia postemergentná aplikácia herbicídu; Polybor 150: 2,5 $l.ha^{-1}$ - prvé fungicídne ošetrenie). Variabilita biologického materiálu ovplyvnila formovanie úrodových parametrov rozdielne. Vplyv odrody na úrodu koreňa bol štatisticky signifikantný. Najvyššia úroda bola zaznamenaná pri odrode Fredonia Nova a najvyšší obsah inulínu v koreni bol pri odrode Maurane.

INTRODUCTION

Formation of chicory (Cichorium intybus L.) yield and technological quality is complex process which is depending on many factors creating the integrated structure of growth and physiological and biochemical processes, as well. Both developmental and matter transformation processes are reflected into growth of chicory biomass. Therefore, the dependence of individual elements of chicory yield formation on environment conditions is very different [3].

In system of field cultivation of chicory plants, the possibilities used of modern approaches are acceptable. Influence of modern approaches on chicory yield and quality production was evaluated as very positive. In addition, application of biological active substances have been used to manage crop growth and improve crop production [7].

The application of biological active substances is one of the potential ways to stabilise the chicory root yield and inulin content. We assume that keystone of plant growth regulators utilization will be not only in increasing of root production but also in decreasing of action environmental stress effects (severe exposure, wrong pesticide application), higher plant resistance to harmful factors and better utilization of others growing measures [12].

Biological active substances participate in regulation of growth and developmental processes in plant. They are affecting the dynamics of yield formation and support the higher utilization of genetic base of variety. The biological active compounds can apply on leaf by spray (foliar application) or given into the soil respectively [10].

Quantification of registered chicory biological material is insufficient in Slovakia. The varieties unsuitable for current harvesting technologies are replaced by new varieties that are less susceptible to mechanical damage. In this regard, the varieties of foreign provenance with high root yield potential and inulin content are the most suitable [4, 5].

The aim of this paper is to evaluate the effects of climatic conditions, biological materials and foliar Atonik and Polybor 150 applications on main productive parameters of chicory (root yield, inulin content in root).

MATERIAL AND METHODS

The field polyfactorial trials were established in warm maize growing area on experimental station of Slovak Agricultural University in Nitra - Dolná Malanta (this locality is situated in south-west part of Slovakia, 173 m above sea level) in 2005 and 2006 years. Trials were set

up by split plot design in which the levels of experiment were assigned at random. Within experiment were three repetitions. Size of experimental plot was 32.4 m^2. Three varieties of chicory (Oesia, Maurane and Fredonia Nova) and three variants of preparation application of Atonik and Polybor 150 were observed (table 1).

The fore crop of chicory was winter wheat. Nutrition doses (NPK) were calculated on the expected yield regarding the nutrient content in the soil. The crop establishment was in accordance with the growing technology of chicory to the final distance of 115 mm in row. Climatic conditions of 2005 and 2006 years are shows in figure 1 and 2.

Atonik is plant-growth regulator, mixture of three aromatic nitro compounds based on nitrophenolates [sodium ortho-nitrophenolate (2 g l^{-1}), sodium para-nitrophenolate (3 g l^{-1}) and sodium 5-nitroguaiakolate (1 g l^{-1})].

Polybor 150 is special high-concentrate foliar fertilizer. Polybor 150 is applied as additional nutrition of agricultural crops, mainly with higher demands on boron. Special fertilizer form (amine-polyborate complex) insures the quickly transfer to plant tissue as well as the wash resistance.

Evaluations of statistical parameters of experimental factors were done by multifactor Analysis of Variance using the statistical software Statgraphics and Excel for Windows.

Table 1: Variants of foliar application of biological active compounds used in field traits
Tabuľka 1: Varianty aplikácie prípravkov použitých v experimente

	Variants (1)	Dose (l ha^{-1}) (2)	Term of applications (3)
K	**Control**	-	-
A	**Atonik**	0.6	2nd post-emergence herbicide application
	Atonik	0.6	3rd post-emergence herbicide application
	Atonik	0.4	2nd post-emergence herbicide application
B	**Atonik + Polybor 150**	0.6 + 2.5	3rd post-emergence herbicide application
	Polybor 150	2.5	1st fungicide treatment

Notes: Poznámky: (1) varianty, (2) Dávka (l.ha-1), (3) termín aplikácie

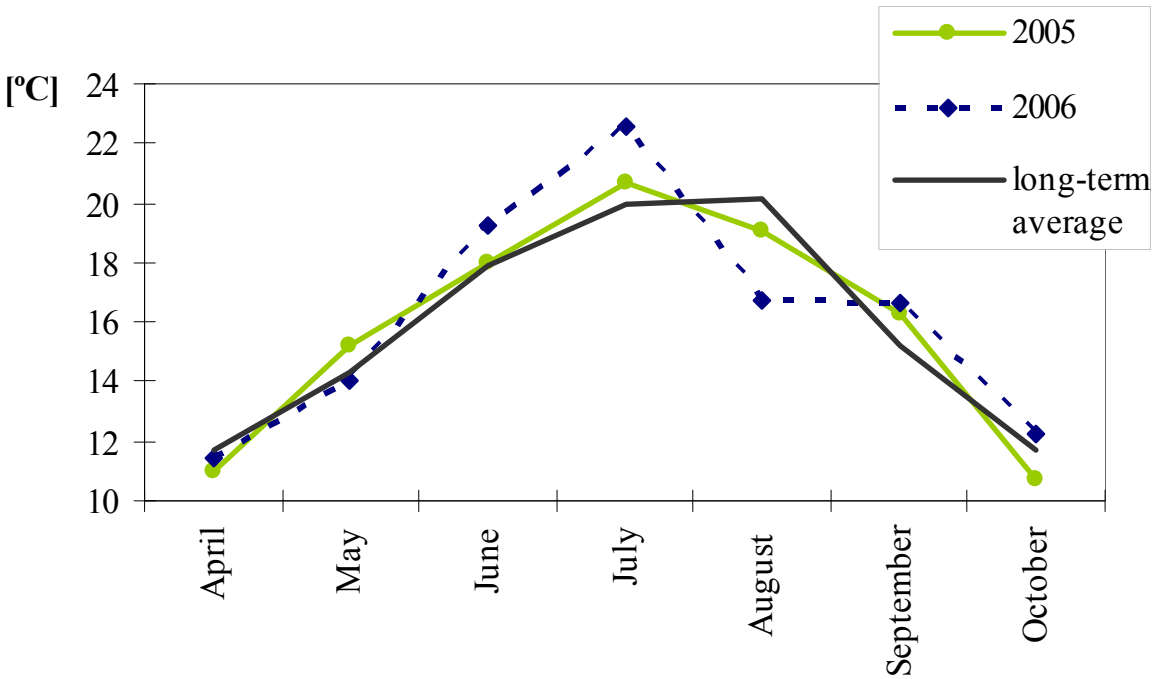

Figure 1: Average of air temperature [ºC] in Nitra during the years 2005 and 2006
Obrázok 1: Priemerná teplota atmosféry [ºC] v Nitre v rokoch 2005 a 2006

RESULTS AND DISCUSSION

Chicory root yield

Average of root yield of chicory, determinated from two years experiment, was 23.87 t ha^{-1} (difference between experimental years was 2.29 t ha^{-1}). Various climatic conditions of years and genetically fixated quality of varieties contributed to these disproportions significantly (table 2). Many authors [1, 6, 8] findings consistent results with us. We support that is necessary to select a variety on the basis of ability to adapt to concrete environment.

The highest of root yield was achieved in variety Fredonia Nova comparing with varieties Oesia (+ 0.06 t ha^{-1}, 2.47 % relatively) and Maurane (+1.31 t ha^{-1}, 5.69 % relatively). Root yield increase of variety Fredonia Nova (comparing with other varieties in each experimental year) was following: Oesia +0.07 (0.27 % relatively) in 2005 year and +0.05 t ha^{-1} (0.21 % relatively) in 2006 year; Maurane:

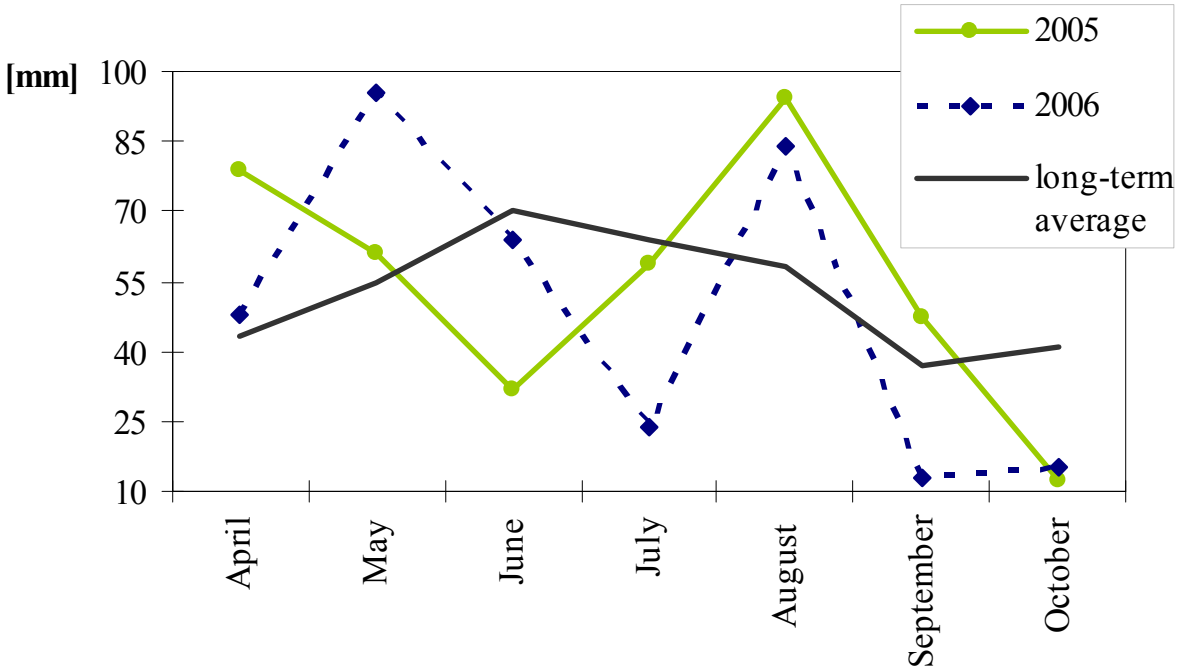

Figure 2: Sum of precipitation [mm] in Nitra during the years 2005 and 2006
Obrázok 2: Úhrn zrážok [mm] v Nitre v rokoch 2005 a 2006

Table 2: Root yield (t ha^{-1}) of chicory
Tabuľka 2: Úroda koreňa (t.ha^{-1}) čakanky obyčajnej

Variety [1]	Year [2]	Experimental variant [3]			Average [7]
		K [4]	A [5]	B [6]	
Oesia	2005	22.14	25.10	29.11	25.45
	2006	20.92	22.91	25.48	23.10
	Average [7]	21.53	24.01	27.29	24.27
Maurane	2005	22.64	25.11	24.52	24.09
	2006	19.63	22.42	23.83	21.96
	Average [7]	21.13	23.76	24.17	23.02
Fredonia Nova	2005	19.13	27.16	30.28	25.52
	2006	20.75	25.33	23.37	23.15
	Average [7]	19.94	26.24	26.82	24.33
Total average		20,86	24,67	26,09	23,87

Notes: Poznámky: [1] odroda, [2] rok, [3] experimentálny variant, [4] kontrola, [5] Atonik, [6] Polybor 150, [7] priemer, [8] total average

Table 3: Inulin content in chicory root (%)
Tabuľka 3: Obsah inulínu v koreni čakanky (%)

Variety [1]	Year [2]	Experimental variant [3]			Average [7]
		K [4]	A [5]	B [6]	
Oesia	2005	18.87	19.19	22.10	19.38
	2006	18.40	18.16	19.15	18.57
	Average [7]	18.13	18.67	19.62	18.97
Maurane	2005	21.13	22.81	21.14	21.69
	2006	20.31	22.93	20.93	21.39
	Average [7]	20.72	22.87	21.03	21.54
Fredonia Nova	2005	19.10	21.17	22.35	20.87
	2006	18.50	20.97	21.87	20.44
	Average [7]	18.80	21.07	22.11	20.65
Total average		19,21	20,87	20,92	20,38

Notes: Poznámky: [1] odroda, [2] rok, [3] experimentálny variant, [4] kontrola, [5] Atonik, [6] Polybor 150, [7] priemer, [8] total average

Table 4: Analysis of variance for chicory root yield and inulin content
Tabuľka 4: Analýza variancie úrody koreňa a obsahu inulínu čakanky obyčajnej

Source of variance [1]	Root yield [2]	Inulin content in root [3]
	P – value [4]	
Year [5]	0.000 $^{++}$	0.000 $^{++}$
Variety [6]	0.0046^{+}	0.020 $^{++}$
Biologically active compounds and fertilizers [7]	0.0056^{++}	0.011 $^{++}$

$^{++}$ Statistically significant differences on value α = 0.05 [8]
Notes: Poznámky: [1] zdroj premenlivosti, [2] úroda koreňa, [3] obsah inulínu v koreni, [4] P – hodnota, [5] rok, [6] odroda, [7] biologicky aktívne látky a hnojivá, [8] štatisticky významné rozdiely na úrovni α = 0,05

+1.43 t ha^{-1} (5.93 % relatively) in 2005 year and +1.19 t ha^{-1} (5,41 % relatively) in 2006 year. Variety affected the root yield statistical high significantly (table 4 and 5).

Regarding to the leaf treatment, foliar application of biological active substances Atonik as well Polybor 150 increased the root yield high significantly. The maximal yield increase, on average, was found at the variant B (the yield increase was 5.23 t ha^{-1} (25.07 % relatively) comparing with variant K and 1.42 t ha^{-1} (5.75 % relatively) comparing with variant A). In 2005 year, the increase of yield was 6.67 t ha^{-1} (31.31 % relatively) at the variant B comparing with control variant and comparing with variant A it was increase about 2.18 t ha^{-1} (8.45 % relatively). In 2006 year the highest yield was at the variant B and differences between variant K were 3.79 t ha^{-1} (18.55 % relatively) and variant A were 0.67 t ha^{-1} (2.84 % relatively)., respectively. Authors [9] and [13] found the similar tendency of yield increase by application of biological active compounds. Finding attributes of analyses variance are presented in table 4 and 5.

Inulin content in root

Analytically estimated inulin content in root of chicory was 20.55 % (on average). The variances between maximal (2005) and minimal values (2006) were 0.77 % (statistically high significant) (table 3). The differences in inulin content reflected the effect of agri-ecological conditions on quality formation of chicory (precipitation were distributed regularly). This finding is in accordance with numerous observations [2, 10, 11].

Inulin content in root was affected by individual varieties high significantly. We found the highest inulin content, on average, in variety Maurane (+2.57 %) in compare with variety Oesia and (+0.89 %) with variety Fredonia Nova, respectively.

Leaf application of Atonik and Polybor 150 influenced inulin content of chicory statistical high significantly. The highest inulin content, on average of individual experiment, was observed in variant B. There was increasing of inulin content at 1.92 % (9.90 % relatively) comparing with control variant (K) and at 0.44 % (2.10 % relatively) comparing with variant A. Increase of inulin

Table 5: Multiple range test (LSD test)
Tabuľka 5: Multiple range test (Mnohonásobné porovnávanie s hraničnými diferenciami) (LSD test)

Evaluated factor [6]	α [2]	Evaluated parameter [1]	
		Root yield [3]	Inulin content in root [4]
		LSD value [5]	
Year [7]	0.05	0.93	0.43
	0.01	0.69	0.33
Variety [8]	0.05	1.04	0.53
	0.01	0.85	0.40
Biologically active compounds and fertilizers [9]	0.05	1.47	0.69
	0.01	1.10	0.52

Notes: Poznámky: [1] sledovaný parameter, [2] □, [3] úroda koreň, [4] obsah inulínu v koreni, [5] LSD hodnoty, [6] sledovaný faktor, [7] rok, [8] odroda, [9] biologicky aktívne látky a hnojivá

content in root of chicory in variant B was observed at each experimental year: comparing with variant K + 2.26 % (11.47 % relatively) and variant A + 0.91 % (4.32 % relatively) in 2005 year and comparing with variant K + 0.58 % (8.28 % relatively) and variant A – 0.03 % (99.85 % relatively) in 2006 year, respectively. Finding values of Analysis of Variance are shows in table 4 and 5.

Conclusion

Globally, the root yield and inulin content in root were influenced by climatic conditions during years, us well as by biological materials and Atonik and Polybor 150 applications. Higher root yield was achieved by variety Fredonia Nova, at the variant B (25.73 t ha^{-1}) and in 2005 year (25.02 t ha^{-1}). The inulin content in root of chicory plants was the highest in 2005 year (20.55 %) and at variant B (20.85 %) with variety Maurane (21.54 %).

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REFERENCES

[1] Amaducci S., Pritoni G., Effect of harvest date cultivar on Cichorium intybus yield components in north Italy, Industrial Crops and Products (1997) 7: 345-349.

[2] Baert R.A., The effect of sowing and harvest date cultivar on inulin yield and composition of chicory (Cichorium intybus L.) roots, Industrial Crops and Products (1996) 6: 195-199.

[3] Bajči P., Klescht V., Yield and sugar content of sugar beet in relation to the basic factors, Rostlinná výroba (Plant, Soil and Environment) (1979) 25: 385-397.

[4] Černý I., Rationalization in Chicory (Cichorium intibus L.) growing, Agromanual (2006) 1: 55-59.

[5] Černý I., Javor D., Variety – an important intensification factor of Chicory (Cichorium intybus L.) growing, Naše pole (2004) 5: 22–25.

[6] Černý I., Pačuta V., Quality of sugar beet root in relation to weather conditions and different Atonik doses, Journal Central European Agriculture (2003) 4: 419-426.

[7] Černý I., Pačuta V., Villár G., Influence of Atonik on sugar beet yield and technological quality, Listy cukrovarnícké a řepařské (2000) 116: 316-319.

[8] Ernst M., Chatterton J., Carbohydrate changes in chicory (Cichorium intybus L. var. Foliosum) during growth and storage, Scientia horticulare (1995) 63: 251-261.

[9] Figueira M.G., Park K.J., Evaluation of desorption isotherms, drying rates and inulin concentration of chicory roots (Cichorium intybus L) with and without enzymatic inactivation, Journal of food engineering (2004) 63: 273-280.

[10] Hébette L.M., Delcour J.A., Complex melting of semi - crystalline chicory (Cichorium intybus L.) root inulin, Carbohydrate Research (1988) 31: 65-75.

[11] Meijer W.J., Mathijssen E.W.J.M., Analysis of crop performance in research on inulin, fibre and oilseed crops, Industrial Crops and Products (1996) 5: 253-264.

[12] Pulkrábek J., Zahradníček J., Growth regulators in sugar beet growing, Řepařství 1998 (Proceedings), Praha, KRV ČZU, (1998) 142-145.

[13] Uher A., Exploitation of natural zeolite in vegetable growing, Acta horticulturae et regiotecturae (2004) 7: 77-79.