EFFECT OF FOLIAR PREPARATIONS AND VARIETY ON SUGAR BEET YIELD AND QUALITY

VPLYV LISTOVÝCH PREPARÁTOV A ODRODY NA ÚRODU A KVALITU CUKROVEJ REPY

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ABSTRACT

Field experiments were conducted at the medium heavy luvisol under the unirrigated conditions at the locality with continental climate in the years 2002 and 2003. Foliar preparations ´Avit 35´ and ´Humix univerzál plus´ were sprayed at the sugar beet leaves during the vegetation. These liquid foliar preparations contain growth stimulators (humates, ethanolamine, ureasalicylate) enriched by macroelements and microelements. Two sugar beet varieties (STRUBE-DIECKMANN) were involved in the experiment: a rhizomania sensitive one (´Swing´) and a rhizomania tolerant one (´Takt´). The experimental locality was without BNYVV infection. Influence of foliar preparations in interaction with other factors (weather conditions, variety) on sugar beet yield and quality parameters (root yield, digestion, molasses forming substances, refined sugar yield) was evaluated in the experiment.

Foliar preparations high significantly increased the root yield and digestion in the year with sufficient rainfalls and decreased molasses substances content in roots in both experimental years. There were high significant differences in digestion between the varieties. Rhizomania tolerant variety (´Takt´) reached better yield and quality parameters than the rhizomania sensitive variety (´Swing´) in conditions without rhizomania infection.

KEYWORDS: sugar beet, foliar preparations, humates, growth stimulators, BNYVV

ABSTRAKT

V rokoch 2002 a 2003 boli na stredne ťažkej hnedozemi v bezzávlahových podmienkach, na lokalite s kontinentálnym vplyvom počasia založené poľné pokusy s cukrovou repou.

Na porast cukrovej repy boli počas vegetácie aplikované (postrekom na list) preparáty ´Avit 35´ a ´Humix univerzál plus´. Sú to tekuté listové prípravky na báze bioaktívnych látok (humáty, etanolamín, ureasalicylát) so stimulačnými účinkami a s relatívne nízkym obsahom makroelementov a mikroelementov. Do pokusu boli zaradené dve odrody cukrovej repy (STRUBE-DIECKMANN), pričom jedna bola citlivá na rizomániu (´Swing´) druhá bola BNYVV tolerantná (´Takt´). Pokusná lokalita patrí medzi oblasti bez výskytu rizománie.

V pokuse bol hodnotený vplyv aplikácie listových preparátov v interakcii s ďalšími faktormi (poveternostné podmienky, odroda) na parametre úrody a kvality cukrovej repy (úroda buliev, cukornatosť, obsah melasotvorných látok, úroda rafinády).

Listové preparáty zvýšili úrodu buliev, digesciu a úrodu rafinády iba v roku s dostatočnými zrážkami. V suchom roku neovplyvnili úrodu buliev a znížili cukornatosť. V oboch experimentálnych rokoch listové preparáty znížili obsah K^+ a Na^+ v buľvách a neovplyvnili obsah αN. Listové preparáty významnejšie vplývali na úrodu cukrovej repy než na jej kvalitu.

Odroda ´Takt´ tolerantná voči rizománie dosiahla vyššiu úrodu buliev, digesciu a úrodu polarizačného cukru než citlivá odroda ´Swing´. Medzi odrodami neboli zistené žiadne rozdiely v reakcii na listové preparáty pri žiadnom zo sledovaných parametrov.

KĽÚČOVÉ SLOVÁ: cukrová repa, listové preparáty, humáty, rastové stimulátory, BNYVV

INTRODUCTION

Possibilities of utilization of various biologically active matters for regulation of sugar beet growing process have been investigated as in Slovakia as in the world. Biologically active matters often use to be the components of foliar fertilizers of new generation being mixed together with macro- and micronutrients [6, 7]. Following matters can be considered the bioactive matters: plant hormones (auxins, cytokinins), preparations supporting ethylene production (chlormequat), matters intervening the polyamines synthesis (ethanolamine, urea salicylate), humic acids, fulvic acids and their salts - humates - containing carboxyl, carbonyl, quinonoid structural groups.

´Avit 35´ [7] is one of the representatives of the new generation of liquid fertilizers. The basic organic substance of the preparation – ethanolamine – intervenes into the polyamines biosynthesis by ornithine decarboxylase inhibition and also by inhibition of enzymatic processes at the ethylene biosynthesis, which is influenced by ureasalicylate in mixture with urea.

´Humix univerzál plus´ is the next representative of the new generation of the liquid fertilizers. The main components are humates. Humates are widespread carbonic matters being formed in the processes of biological and chemical decomposition of plant and animal residues. They create approximately 75 % of organic matter in the soil. Humates present the complex of high molecular polyfunctional nitrogenic organic compounds with cyclic structure and specific physical, chemical and biological characteristics [8, 9]. Humic substances reportedly enhance the growth of numerous crops; however, little information is available as to their effects on sugar beet [1]. Favorable influence of humates is known like the stimulation of nutrients income by plants and positive affection of the final production [4, 12, 15]. As the result of these processes the nutrients income is regulated during the vegetation, which leads to the yield increasing and quality improvement of the agricultural products [8].

Selection of appropriate variety is an important intensification element at the sugar beet cultivation. Rhizomania has become the illness which strongly influences the variety structure at the market [10]. The only remediation how to eliminate the yield losses caused by rhizomania is growing of the tolerant varieties [11]. The aim of selection and cultivation is variety tolerance maintaining high productivity and high raw material quality [2].

The purpose of this contribution is to investigate the effect of foliar preparations (´Avit 35´ and ´Humix univerzál plus´) on the sugar beet yield and quality in interaction with other factors (weather conditions, variety) and to find out the potential difference in production characteristics between rhizomania sensitive and tolerant sugar beet varieties in conditions without rhizomania infection.

MATERIAL AND METHODS

Field polyfactorial experiments were established in the years 2002 - 2003, by the method of split plots, at the experimental locality of Slovak University of Agriculture in Nitra, Dolná Malanta (without BNYVV infection, unirrigated conditions). The soil-climatic characteristics are stated in the table 1. The locality belongs to the warm and slightly dry climatic region with continental type of weather.

Sugar beet was cultivated in 4-year crop rotation; winter wheat was a forecrop. After the postharvest stubble-breaking cattle manure was ploughed by medium ploughing together with potassium, followed by deep ploughing. Potassium was applied in form of potassium chlorid, according the table 2. Phosphorus was not applied due to soil sufficient supply. Nutrition rates (NPK - fertilizers) were calculated on the expected yield 50 $t.ha^{-1}$, regarding the nutrients content in the soil. Before-sowing soil cultivation was done by combinatory, with sowing on the final positions (165 mm in row). Nitrogen was applied in the form of ammonium nitrate + sulphur, according to the tables 1 and 2 in the single pre-sowing rate.

Three factors were observed in the experiment:

A: Foliar treatment by the preparations

B: Varieties

C: Year (air temperatures and precipitation)

A. Three levels of leaves treatment were applied:

a_1 – NPK + manure (control)

a_2 – NPK + manure + ´Avit 35´ (foliary treatment – spraying) (18 l. ha^{-1} in stage of the 11. - 13. leaves) (EPPO Crop Growth Stage Keys, 1984, DC 30)

a_3 - NPK +´Humix univerzál plus´ (foliary treatment – spraying) (applied in two doses: the 1-st time in the stage of the 11. - 13. leaves, 8 l. ha^{-1} , EPPO Crop Growth Stage Keys, 1984, DC 30 and the 2-nd time in the stage right before full foliar canopy 8 l. ha^{-1}, EPPO Crop Growth Stage Keys, 1984, DC 45)

´Avit 35´ is a liquid foliar fertilizer based on ureasalicylate, ethanolamine and urea enriched by 4.4 % N, 3.9 % Mg, 15.8 % C, and microelements (5.1 %).

´Humix plus univerzál´ is a liquid soil or foliar fertilizer containing potassium humate (4%), enriched by 4.5 % N, 0.53 % P, 3.23 % K, and Fe, Mg, Zn, Cu, Mo, B.

Table 1: Soil-climatic characteristics of the locality
Tabuľka 1: Pôdno-klimatická charakteristika stanovišťa

Indicator (ukazovateľ)			Value (hodnota)	
Above sea level (nadmorská výška)			172.5 m n. m.	
Production area (výrobná oblasť)			maize (kukuričná)	
Climate (klíma)	Climatic region (klimatická oblasť)		warm. slightly dry (teplá. mierne suchá)	
	Average air temperature (priemerná teplota vzduchu)		9.7 °C	
	Per years (za roky)			
		Per vegetation (za vegetáciu)	15.4 °C	
	Sum of precipitaton (súhrn zrážok)	Per years (za roky)	561 mm	
		Per vegetation (za vegetáciu)	386 mm	
Soil (pôda)	Soil type (pôdny typ)		Medium heavy luvisol (hnedozem kultizemná) (Hma)	
	ph (KCl)		5.54	
	Year (rok)		2002	2003
	Content (obsah) (mg.1000 g $^{-1}$) (Mehlich II)	P (Egner)	45	26
		K (Schachts.)	232	140
		Mg (Schachts.)	207	191
		humus (Tjurin) (%)	2.46	1.98

Table 2: Trial scheme (doses of NPK fertilizers)
Tabuľka 2: Schéma pokusu (dávky NPK hnojív)

Application (aplikácia)			2002	2003
Nutrients* (živiny)*	N (kg.ha^{-1})		166.17	150
	P (kg.ha^{-1})		-	-
	K (kg.ha^{-1})		68	180
Foliar preparation (listový preparát)	phase of 11.-13. leaves (fáza 11. – 13. listov)	Avit 35	18 l.ha^{-1}	
		Humix univerzál plus	8 l.ha^{-1}	
	phase of full canopy (fáza plného zapojenia)	Humix univerzál plus	8 l.ha^{-1}	

B. Two single-germ sugar beet varieties were observed:

b_1 - ´Swing´ (rhizomania sensitive)

b_2 - ´Takt´ (rhizomania tolerant)

During the experiment, ELISA tests were performed every year. Negative test indicated that BNYVV, if present, was not detected.

Sugar beet quantitative and qualitative production parameters were observed in the experiment: root yield (RY) (t.ha^{-1}), digestion (Dg) (°S), polarized sugar yield (PSY) (t.ha^{-1}), ashes ($K^+ + Na^+$) content (mmol.100 g^{-1}), α-amino Nitrogen content (mmol.100 g^{-1}). Polarized sugar yield was calculated according the formula: PSY = RY x Dg x 0.01 [t.ha^{-1}].

Data were evaluated by Multifactor Analysis of Variance (LSD test) and Analysis of Nested Designs.

RESULTS AND DISCUSSION

Root yield

In the year 2002 with sufficient rainfalls (figures 1 and 2) the root yield was increased significantly after ´Humix univerzál plus´ and ´Avit 35´ treatment (tables 3, 4, 5). In the arid year 2003 there were no significant differences between control and treated canopies in the root yield

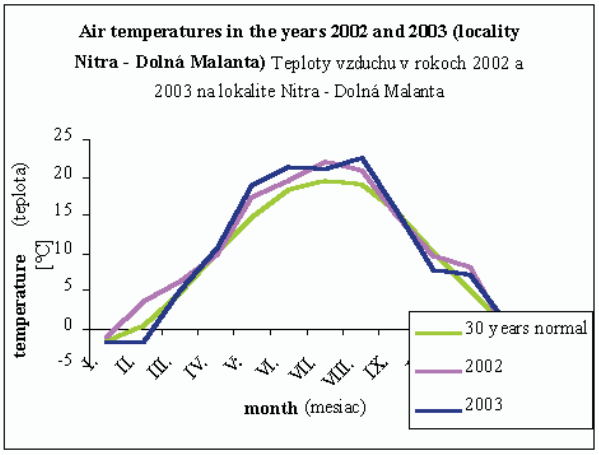

Figure 1: Air temperatures development comparing to 30 – years normal

Graf 1: Priebeh teplôt vzduchu v porovnaní s 30-ročným normálom

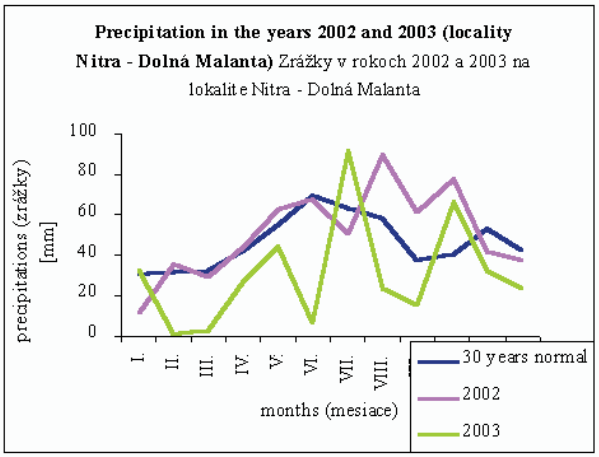

Figure 2: Precipitation on the experimental locality comparing to the 30 – years normal

Graf 2: Zrážkové pomery na pokusnej lokalite v porovnaní s 30- ročným normálom

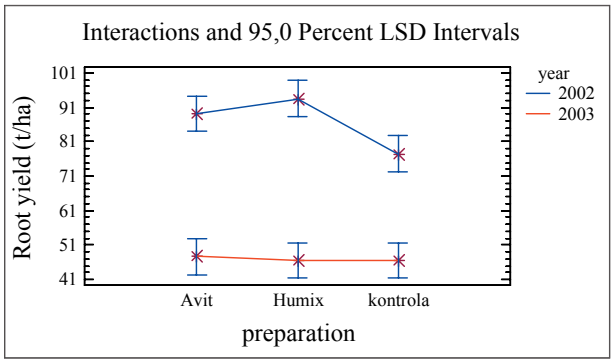

Figure 3: Root yield depending on years and foliar preparations

Graf 3: Úroda buliev v závislosti od ročníkov a listových preparátov

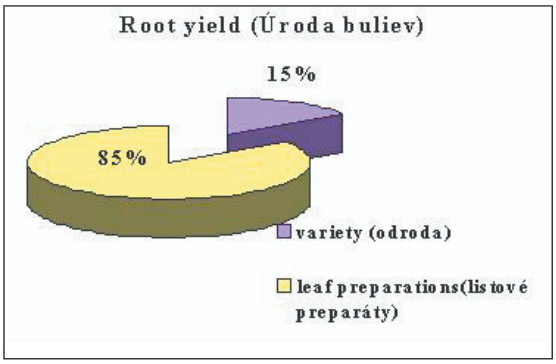

Figure 4: Ratio of influence of individual factors (variety and foliar preparations) on the root yield according to Analysis of Nested Designs

Graf 4: Pomer vplyvu jednotlivých faktorov (odroda a listové preparáty) na úrodu buliev podľa hierarchickej analýzy

(figure 3).

Antistress drought effects of salicylic acid (one of the ´Avit 35´ components) were investigated in association with enzymatic processes stimulation followed by the increased plant drought resistance [7]. This effect was not confirmed in our experiments.

Three weeks after ´Avit 35´ application increased content of auxins in plant cells, thereby plant growth was stimulated [8]. This was confirmed only in the year 2002 with sufficient rainfalls. Humate chelates complexes with microelements can get easier to the plant cell than the common ions [8]. Author noticed increasing of sugar beet root yield at 37 %. In our experiment it was at 12 - 14 %.

Regarding the root yield effect of foliar preparations was bigger (85 %) than effect of varieties (15%) (Analysis of Nested Designs) (figure 4). There was no significance difference between rhizomania tolerant and rhizomania sensitive variety in root yield at the locality without rhizomania infection (table 3). There were no differences in root yield in reaction on foliar preparations treatment between varieties (table 3).

Digestion

Influence of foliar preparations on sugar beet digestion was not statistically significant in average of years 2002 and 2003 (tables 2, 3, and 6). This was confirmed by [13, 14]. They state that application of biologically active matters affects more significantly quantity of production

Table 3: Analysis of variance – Anova table
Tabuľka 3: Analýza rozptylu – Stupne preukaznosti vplyvov jednotlivých faktorov na parametre

source of variability	Root yield	Digestion	Na	ashes (K + Na)	α amino N	Refined sugar yield
				significance level		
Variety (Odroda)	0.6607	0.0000**	0.0000**	0.0000**	0.0109*	0.0027**
Foliar preprarations (Listové preparáty)	0.0038**	0.1203	0.0007**	0.0000**	0.1274	0.0003**
Repetition (Opakovanie)	0.3896	1.0000	0.9978	0.9972	0.9721	0.3092
Year (Ročník)	0.0000**	0.0000**	0.0000**	0.0000**	0.9721	0.0000**
Variety x Foliar. pr. (Odroda x List. pr.)	0.9467	0.3527	0.0684	0.0000**	0.0629	0.3687
Variety x Year (Odroda x rok)	0.0992	0.0702	0.1046	0.0000**	0.7330	0.0008**
Preparations x year (Preparáty x Rok)	0.0060**	0.0035**	0.0002**	0.0056**	0.2152	0.0003**

Table 4: Analysis of variance - Multiple range test (LSD test)
Tabuľka 4: Analýza rozptylu – Stupne preukaznosti vplyvov jednotlivých faktorov na parametre

Factor	α	Observed parameter (Sledovaný parameter)					
		Úb LSD values	Dg	Na	K+Na	αN	Úraf.
Variety (Odroda)	0.05	3.80	0.22	0.06	0.10	0.21	0.71
	0.01	5.16	0.30	0.082	0.14	0.28	0.96
Foliar preparations (Listové prípravky)	0.05	4.66	0.27	0.07	0.13	0.25	0.87
	0.01	6.33	0.37	0.10	0.171	0.34	0.17
Year (Ročník)	0.05	3.81	0.22	0.06	0.10	0.21	0.71
	0.01	5.17	0.30	0.08	0.14	0.28	0.96

Table 5: Root yield depending on varieties. foliar preparations and years ($t.ha^{-1}$)
Tabuľka 5: Úroda buliev závislá od odrôd. listových preparátov a ročníka ($t.ha^{-1}$)

varieties	foliar preparations	Root yield - úroda buliev								
		2002			2003			years - average		
		$t.ha^{-1}$	Δ	rel. %	$t.ha^{-1}$	Δ	rel. %	$t.ha^{-1}$	Δ	rel. %
´SWING´	control	75.92	0	100	47.22	0	100	61.57	0	100
	Avit 35	82.40	+6.48	109	47.69	+0.47	101	65.05	+3.48	106
	Humix un. plus	90.74	+14.82	120	49.17	+1.95	104	69.96	+8.39	114
	$\bar{x}_{BNYVV\ sensitive}$		83.02			48.02			65.52	
´TAKT´	control	79.01	0	100	45.60	0	100	62.31	0	100
	Avit 35	82.87	+3.86	105	47.59	+1.99	104	65.23	+2.93	104.7
	Humix un. plus	96.30	+17.29	122	43.89	-1.71	96	70.10	+7.79	112.5
	$\bar{x}_{BNYVVresistant}$		88.68			45.69			67.19	
average $_{both\ varieties}$			84.87			46.86			65.86	

Table 6: Digestion depending on varieties. foliar preparations and years (°S)
Tabuľka 6: Cukornatosť v závislosti od odrôd. listových preparátov a ročníka (°S)

varieties	foliar preparations	Digestion - cukornatosť								
		2002			2003			priemer		
		°S	Δ	rel. %	°S	Δ	rel. %	°S	Δ	rel. %
´SWING´	control	15.31	0	100	21.12	0	100	18.22	0	100
	Avit 35	16.17	+0.86	106	20.14	-0.98	95	18.16	-0.06	100
	Humix un. plus	16.5	+1.19	108	20.37	-0.75	96	18.44	+0.22	101
	$\bar{x}_{BNYVV\ sensitive}$		15.99			20.54			18.27	
´TAKT´	control	16.83	0	100	20.85	0	100	18.84	0	100
	Avit 35	16.99	+0.16	101	21.33	+0.48	102	19.16	+0.32	101.7
	Humix un. plus	17.15	+0.32	102	21.22	+0.37	102	19.19	+0.34	101.8
	$\bar{\bar{x}}_{BNYVVresistant}$		16.99			21.13			19.06	
average $_{both\ varieties}$			16.49			20.84			18.66	

Table 7: Content of $K^+ + Na^+$ depending on varieties. foliar preparations and years (mmol. $100g^{-1}$)
Tabuľka 7: Obsah $K^+ + Na^+$ v závislosti od odrôd. listových preparátov a ročníka (mmol. $100g^{-1}$)

varieties	foliar preparations	content of $K^+ + Na^+$								
		2002			**2003**			**priemer**		
		(mmol. $100g^{-1}$)	Δ	rel. %	(mmol. $100g^{-1}$)	Δ	rel. %	(mmol. $100g^{-1}$)	Δ	rel. %
´SWING´	control	6.24	0	100	5.78	0	100	6.01	0	100
	Avit 35	5.57	-0.67	89	5.68	-0.10	98	5.63	-0.39	94
	Humix un. plus	5.04	-1.20	81	5.36	-0.42	93	5.20	-0.81	87
	$\bar{x}_{BNYVV\ sensitive}$		5.61			5.6			5.61	
´TAKT´	control	4.76	0	100	5.5	0	100	5.13	0	100
	Avit 35	4.55	-0.21	96	5.49	-0.01	100	5.02	-0.11	97.9
	Humix un.plus	4.67	-0.09	98	5.39	-0.11	98	5.03	-0.10	98.1
	$\bar{\bar{x}}_{BNYVVresistant}$		4.66			5.46			5.06	
average $_{both\ varieties}$			5.14			5.53			5.34	

Table 8: Content of α amino N depending on varieties. foliar preparations and years (mmol. $100g^{-1}$)
Tabuľka 8: Obsah α amino N v závislosti od odrôd. listových preparátov a ročníka (mmol. $100g^{-1}$)

varieties	foliar preparations	content of α amino N								
		2002			**2003**			**priemer**		
		(mmol. $100g^{-1}$)	Δ	rel. %	(mmol. $100g^{-1}$)	Δ	rel. %	(mmol. $100g^{-1}$)	Δ	rel. %
´SWING´	control	5.2	0	100	6.14	0	100	5.67	0	100
	Avit 35	4.66	-0.54	90	5.79	-0.35	94	5.23	-0.45	92
	Humix un plus	4.23	-0.97	81	6.48	+0.34	106	5.36	-0.32	94
	$\bar{x}_{BNYVV\ sensitive}$		4.7			6.13			5.42	
´TAKT´	control	4.66	0	100	6.77	0	100	5.72	0	100
	Avit 35	5.16	+0.50	111	6.55	-0.22	97	5.86	+0.14	102.4
	Humix un.plus	4.89	+0.23	105	6.03	-0.74	89	5.46	-0.26	95.5
	$\bar{\bar{x}}_{BNYVVresistant}$		4.9			6.45			5.68	
average $_{both\ varieties}$			4.80			6.29			5.55	

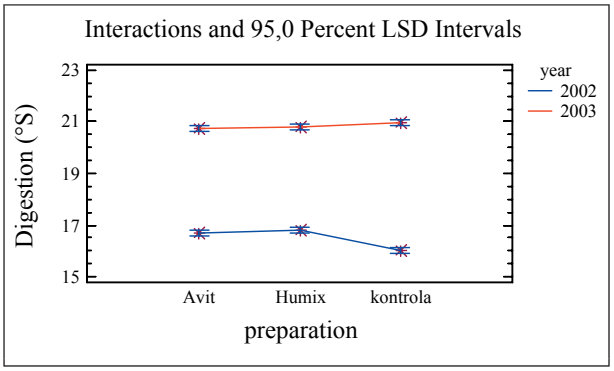

Figure 5: Digestion depending on foliar preparations and years

Graf 5: Digescia v závislosti od listových preparátov a rokov

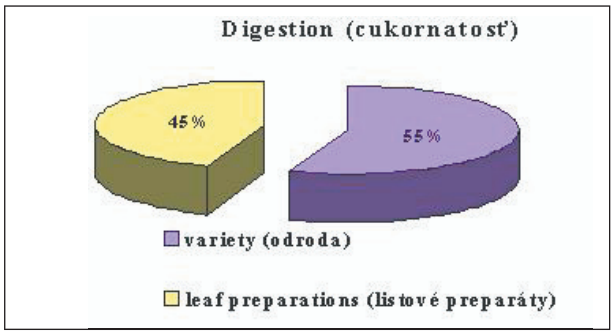

Figure 6: Ratio of influence of individual factors (variety and foliar preparations) on digestion according to Analysis of Nested Designs

Graf 6: Pomer vplyvu jednotlivých faktorov (odroda a listové preparáty) na cukornatosť podľa hierarchickej analýzy

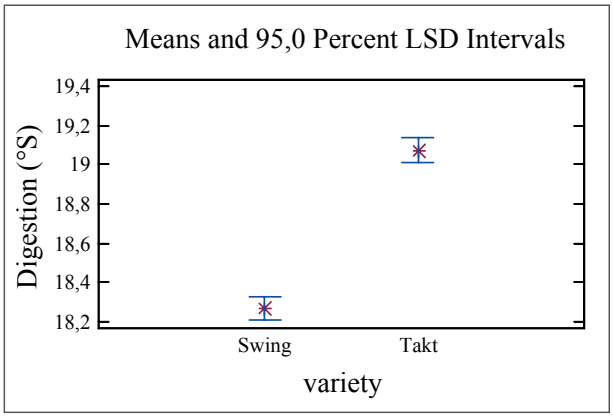

Figure 7: Digestion depending on variety in average of years 2002 and 2003

Graf 7: Cukornatosť v závislosti od odrody v priemere rokov 2002 a 2003

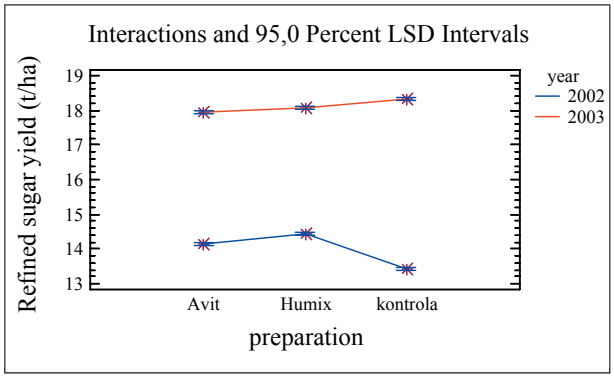

Figure 8: Refined sugar yield depending on foliar preparations and years

Graf 8: Úroda rafinády v závislosti na listových preparátoch a rokoch

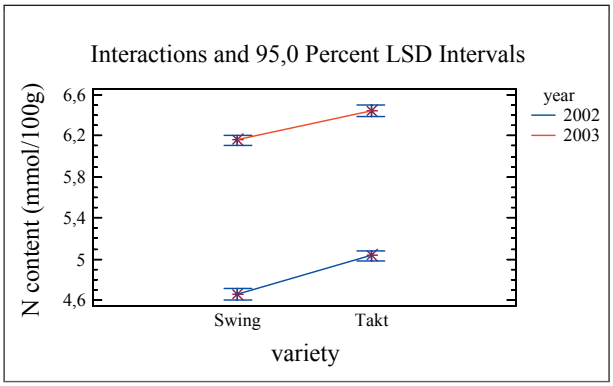

Figure 9: Content of αN in sugar beet roots influenced by varieties and years

Graf 9: Obsah αN v buľvách cukrovej repy vplyvom odrôd a ročníkov

than its quality, given mainly by digestion. As we can see at the figure 4, in the year 2002 which was sufficient in rainfalls digestion was statistically significantly increased after treatment by foliar preparations.

Variety influenced digestion in larger scale than the foliar treatment (55% : 45%) (figure 6). At the figure 7 we can see that rhizomania tolerant variety 'Takt' reached statistically significantly higher digestion than rhizomania sensitive variety 'Swing'.

There were no differences in digestion in reaction on foliar preparations treatment between varieties (table 3).

$K^+ + Na^+$ (ashes) and αN content, refined sugar yield

Foliar preparations statistically high significantly decreased the ashes content (tables 3, 4, 7), they did not affect αN content (table 8) and statistically high significantly increased refined sugar yield in average of years 2002 and 2003 (table 9). In molasses forming substances there was no difference between years but

Table 9: Refined sugar yield depending on varieties. foliar preparations and years (mmol. $100g^{-1}$)
Tabuľka 9: Úroda rafinády v závislosti od odrôd. listových preparátov a ročníka (mmol. $100g^{-1}$)

varieties	foliar preparations	Refined sugar yield - Úroda rafinády								
		2002			2003			priemer		
		$t.ha^{-1}$	Δ	rel. %	$t.ha^{-1}$	Δ	rel. %	$t.ha^{-1}$	Δ	rel. %
´SWING´	control	9.42	0	100	8.63	0	100	9.03	0	100
	Avit 35	11.15	+1.73	118	8.28	-0.35	96	9.72	+0.69	108
	Humix un. plus	12.78	+3.36	136	8.67	+0.04	100	10.73	+1.70	119
	$\bar{x}_{BNYVV\ sensitive}$		11.12			8.53			9.83	
´TAKT´	control	11.41	0	100	8.23	0	100	9.82	0	100
	Avit 35	13.36	+1.95	117	8.82	+0.59	107	11.09	+1.27	112.9
	Humix plus	14.26	+2.85	125	8.13	-0.10	99	11.20	+1.38	114.0
	$\bar{x}_{BNYVVresistant}$		13.01			8.39			10.70	
average $_{both\ varieties}$			12.06			8.46			10.26	

refined sugar yield was increased by foliar preparations only in year 2002 with sufficient rainfalls and was decreased in arid year 2003 comparing to control (figure 8).

[6] states that after ´Avit 35´ refined sugar yield increased at 2.45 $t.ha^{-1}$ (year 1992), at 3.15 $t.ha^{-1}$ (1993), at 2.70 $t.ha^{-1}$ (1994), at 2.70 $t.ha^{-1}$ (1995), and at 1.24 $t.ha^{-1}$ (1996).

Technological quality of sugar beet is given in large scale by appropriate choice of variety. In conditions without BNYVV variety ´Takt´ (rhizomania resistant) reached better technological parameters than variety ´Swing´ (rhizomania sensitive) (except from αN content, figure 9). This confirmed results of [2, 3], that the newest sugar beet varieties BNYVV resistant reach almost the same results like the sensitive varieties on the localities without BNYVV infection.

CONCLUSIONS

- Foliar preparations increased the root yield, digestion and refined sugar yield only in year with sufficient rainfalls. In arid year they did not affect root yield and refined sugar yield and decreased digestion.
- Foliar preparations significantly decreased content of K^+ and Na^+ in both experimental years (2002 an 2003) and they did not affect αN content.
- Foliar preparations affected more significantly quantity of sugar beet production than its quality.
- Rhizomania resistant variety ´Takt´ reached significantly higher root yield, digestion and polarized sugar , lower ashes content but also higher content of αN than sensitive variety ´Swing´ than in conditions without BNYVV
- No differences between varieties ´Swing´ and ´Takt´ in reaction on foliar treatment were found.

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