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Influence of selected agrotechnical measures and climate conditions on root yield and digestion of sugar beet

Vplyv vybraných agrotechnických opatrení a klimatických podmienok na úrodu buliev a cukornatosť repy cukrovej

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Abstract

In the years 2014 and 2015 was in field conditions founded polyfactorial experiment, where was observed impact of selected varieties of sugar beet (Antek, Kant, Galvani, Kosmas), biopreparations (Alga 300 P + Alga 300 K, Alga 600) and also weather conditions of the year to main quantitative parameter (root yield) and main qualitative parameter (digestion) of sugar beet. Confirmed was high significant influence of the year condition to both evaluated parameters. Higher root yield was achieved in 2014 on the level 88.67 t*ha^{-1}, which was 29.2 t*ha^{-1} more (rel. + 32.93%) than yield in 2015. Digestion was higher in 2015 on the level 17.67 °S, which was about 1.41 °S (rel. 7.98%) more compared with 2014. Statistically high significant influence of variety was detected on digestion. On an average of both years the highest digestion achieved variety Galvani 17.49 °S. Application of biopreparations has significant influence on root yield. Best results were achieved on treatment, where was applied Alga 600 76.61 t*ha^{-1} (rel. + 5.16%) compared to the control treatment.

Keywords: biopreparations, digestion, root yield, sugar beet, variety, weather conditions

Abstrakt

V poľných podmienkach bol v rokoch 2014 a 2015 založený viacfaktorový pokus, v ktorom sa sledoval vplyv vybraných odrôd repy cukrovej (Antek, Kant, Galvani, Kosmas), biopreparátov (Alga 300 P + Alga 300 K, Alga 600) a tiež poveternostných podmienok ročníka na hlavný kvantitatívny parameter (úroda buliev) a hlavný kvalitatívny parameter (digescia). Štatistickým hodnotením získaných výsledkov sa

potvrdil vysoko preukazný (P < 0.01) vplyv ročníka na oba sledované parametre. Vyššia úroda buliev sa dosiahla v roku 2014 a to 88.67 t*ha^{-1}, čo bolo o 29.2 t*ha^{-1} viac (rel. + 32.93%) v porovnaní s rokom 2015. Cukornatosť bola naopak vyššia v roku 2015 17.67 °S, čo bolo o 1.41 °S (rel. 7.98%) viac ako v roku 2014. Zistil sa tiež štatisticky vysoko preukazný vplyv odrody na digesciu, v priemere oboch ročníkov dosiahla najvyššiu digesciu odroda Galvani 17.49 °S. Použitie biopreparátu malo štatisticky preukazný vplyv na úrodu buliev. Najlepšie výsledky sa dosiahli pri variante, kde sa aplikoval prípravok Alga 600 76.61 t*ha^{-1} (rel. + 5.16%) v porovnaní s kontrolou.

Kľúčové slová: biopreparáty, cukornatosť, odroda, poveternostné podmienky, repa cukrová, úroda buliev

Detailný abstrakt

Cieľom tohto experimentálneho výskumu založeného v rokoch 2014 a 2015 na Experimentálnej báze Slovenskej poľnohospodárskej univerzity v Dolnej Malante, bolo sledovať vplyv vybraných agrotechnických opatrení (biopreparát a odroda) a priebeh poveternostných podmienok na hlavný kvantitatívny parameter (úroda buliev) a hlavný kvalitatívny parameter (digescia) repy cukrovej. Experimentálna báza je situovaná v Žitavskej pahorkatine, ktorá spadá do kukuričnej výrobnej oblasti. Na danom pozemku sa nachádzajú stredne ťažké hlinité pôdy, pH pôdy je v slabo kyslých hodnotách a pôdny typ je hnedozem. Predplodinou repy cukrovej bola v oboch výskumných rokoch pšenica letná forma ozimná. Pre prípravu pôdy po zbere predplodiny sa zvolil klasický systém obrábania (podmietka, dve orby, urovnanie). Repa cukrová bola vysiata na konečnú vzdialenosť. V pokuse boli použité 4 jednoklíčkové odrody Antek, Kant, Galvani a Kosmas. Počas vegetačnej doby oboch ročníkov boli foliárne aplikované biopreparáty Alga 300 P + Alga 300 K a Alga 600 v dvoch dávkach v rastových fázach podľa metodiky poskytovateľa Agrobiosfer s.r.o. Výsledky boli spracované a vyhodnotené v štatistickom programe Statistica 10 (ANOVA a Tukeyov test). Použitím štatistického hodnotenia sa zistil vysoko preukazný (P < 0.01) vplyv klimatických podmienok ročníka na úrodu buliev, ako aj na digesciu. V roku 2014 sme dosiahli v porovnaní s rokom 2015 vyššiu úrodu buliev o 29.2 t*ha^{-1} (rel. + 32.93%). Naopak, vyššia hodnota digescie sa dosiahli v roku 2015 17.67 °S, čo bolo o 1.41 °S (rel. 7.98%) viac ako v roku 2014. Odroda štatisticky vysoko preukazne (P < 0.01) ovplyvnila ukazovateľ digescia, vplyv odrody na ukazovateľ úroda buliev bol štatisticky nepreukazný. Najvyššia digescia sa dosiahla pri odrode Galvani 17.49 °S, najnižšia digescia sa dosiahla pri odrode Kosmas 16.53 °S, rozdiel medzi týmito odrodami bol preukazný (P < 0.05). Aplikácia biopreparátov mala preukazný vplyv (P < 0.05) na parameter úroda buliev, najlepšie výsledky boli dosiahnuté na variante, kde bol aplikovaný biopreparát Alga 600 76.61 t*ha^{-1}, čo bolo o 3.95 t*ha^{-1} (rel. + 5.16%) viac v porovnaní s kontrolným variantom. Vplyv biopreparátu na parameter digescia bol štatisticky nepreukazný. Výsledky tohto výskumu potvrdili opodstatnenie pre používanie biologicky aktívnych látok v pestovateľskom systéme repy cukrovej.

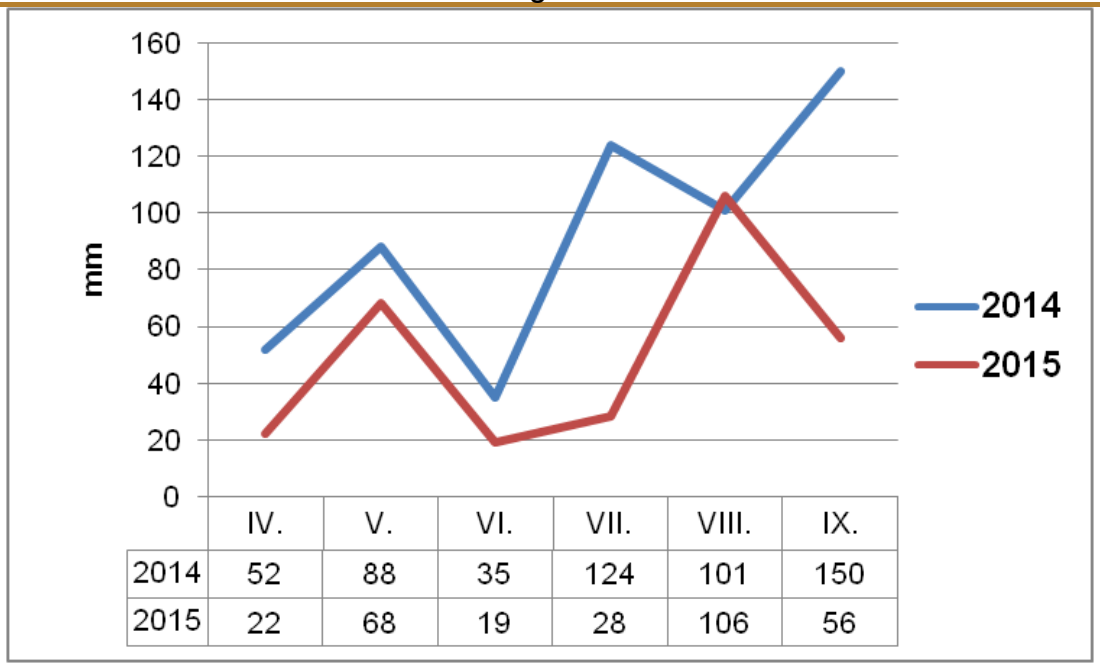
Introduction

Sugar beet is currently in the world considered for the second most important crop, from which can be produced sugar (Leilah et al., 2005). Production process of sugar beet is highly dependent on limiting environmental stress factors, in which crop is grown. Between these factors we include mainly agro-ecological environmental conditions (aridity, nutrient deficiency, heat, etc.) with emphasis on the interaction between them (Černý and Kovár, 2015). The cultivation of culture crops is highly dependent on dose of precipitation. Time distribution, quantity and to a lesser extent type of precipitation has a significant impact on the quantity and quality of yield (Yoder, 2014). The share of the impact of weather conditions on the production parameters of sugar beet is between 10 – 20% (Černý and Pačuta, 2003). Current and ongoing climate changes bringing a many problems, with which will agricultural sector count on, eg.: change of phenological phases, change of agro-climatic production potential, the distribution of precipitations, extending the growing season of the plants etc. (MŽP SR, 2013). Against negative abiotic effects of environment is currently on the market a broad portfolio of products – biopreparations that are trying to keep the plant in optimum condition. These preparations offer a balanced amount of macro and micro elements supplemented by the physiologically active matters such as: humins, humates, amino acids, auxins, cytokinins and others (Roháčik, 2014). Many authors have dealt with the influence of biologically active matters by experimental researches (Pačuta and Karabínová , 2002; Pulkrábek, 2006; Jakiene, 2013). Biopreparations are applied to sugar beet largely foliar and such nutrition is suitable as a supplement to basic nutrition, especially in dry and unfavourable years. It also allows better results of the main parameters in accordance with economic efficiency (Černý and Kovár, 2015; Pačuta et al., 2015).

Materials and methods

Characteristics of the area

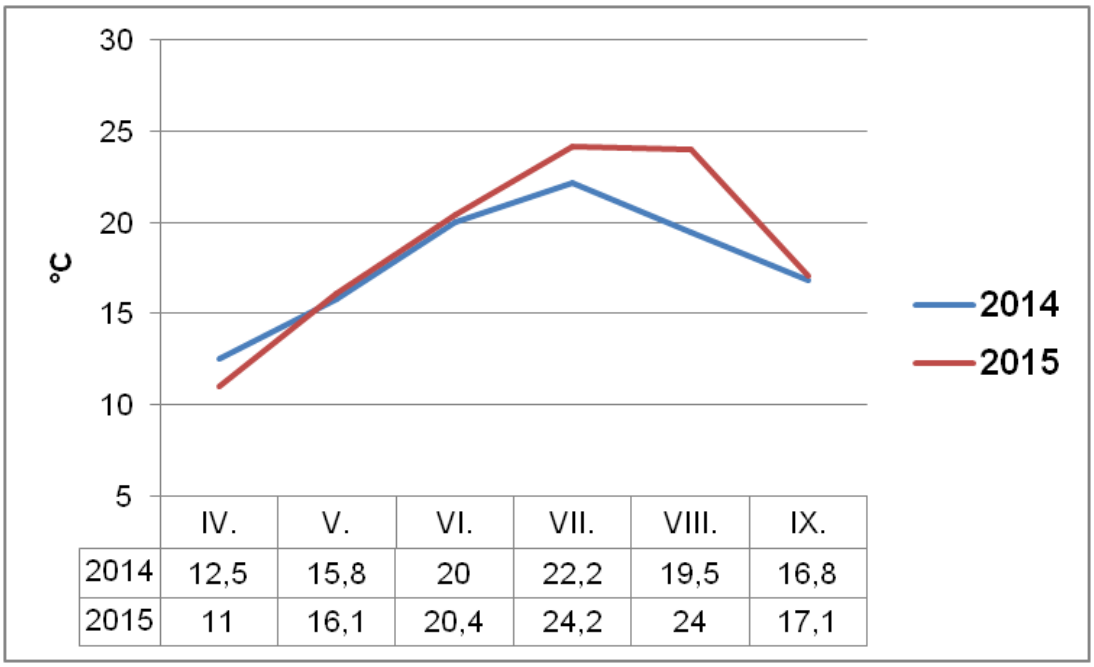
Experimental researches were realized during vegetation years 2014 and 2015 in field conditions on Experimental base of Slovak university of Agriculture, which extends in cadastre of village Dolná Malanta. Location of the base falls within the catchment area of river Nitra and is situated on Žitava´s hilly (Hrnčiarová, 2001). It is a warm climatic region, the average annual temperature is 9.6 °C, with the summ of daily temperatures above 10 °C (3000 °C – 2800 °C). Experimental base is also characterized by a drought, the average rainfall is varies around 540 mm per year. On the land is the main soil unit brown soil, medium duty, loamy soil and without skeleton content (Tobiášová and Šimanský, 2009). In experimental year 2014 rainfall and temperatures corresponded with long – time averages on this area, in contrast in 2015 prevailed extreme drought with high temperatures, which had a negative impact on the final yield of crops (Figure 1 and 2). Polyfactorial experiment was established by randomized split plots design (Ehrenbergerová, 1995).



	IV.	V.	VI.	VII.	VIII.	IX.
2014	52	88	35	124	101	150
2015	22	68	19	28	106	56

Figure 1. Rainfall during growing season 2014 and 2015

Figure 1. Úhrn zrážok počas vegetačného obdobia v rokoch 2014 a 2015



	IV.	V.	VI.	VII.	VIII.	IX.
2014	12,5	15,8	20	22,2	19,5	16,8
2015	11	16,1	20,4	24,2	24	17,1

Figure 2. Temperature during growing season 2014 and 2015

Figure 2. Teploty počas vegetačného obdobia v rokoch 2014 a 2015

Agrotechnical parameters

Forecrop for sugar beet was winter wheat in both years. The crop rotation was composed as follows: 1. Pea (*Pisum sativum*), 2. Winter wheat (*Triticum aestivum*), 3. Sugar beet (*Beta vulgaris var. altissima*), 4. Barley (*Hordeum sativum*). Preparing the soil after harvest of the forecrop and then sowing were used based on

agrotechnical requirements of sugar beet (stubble, deep tillage, medium deep tillage with incorporation of manure, settlement of soil surface and sowing). Fertilization was in accordance with the requirements of crop and doses of nutrients were calculated by balance method based on agrochemical soil analysis after harvest of forecrop (Table 1).

Table 1. Agrochemical soil analysis

Tabuľka 1. Agrochemický rozbor pôdy

Year	Nutrients content (mg*kg^{-1})							pH	Humus	CO_3
	N_{an}	P	K	Na	Mg	Mn	Zn		%	
2014	25.2	5	217	20	291	6.63	1.19	6.07	2.05	0.15
2015	11.75	93	385	28.5	221	6.7	0.65	6.25	1.6	0.05

Sugar beet was harvested manually in the technological maturity, and then were each treatments weighed directly on the field and values were counted to the hectare yield. After weighing representative samples were stored in the bags and sent to the laboratory of sugar factory in Trenčianska teplá to digestion determine.

Sowing and biological material

Sowing of sugar beet seeds was made by 12 rows seeder with technology of sowing on final distance (0.45 m * 0.16 m) in three repetitions for a greater accuracy of experiment. Into experiment four genetically monogerm varieties from Strube s.r.o. – Antek (NZ type), Kant (NZ type), Galvani (N type) and Kosmas (NZ type) – were included.

Biopreparations

In the experiment, effect of biopreparations Alga 300 P + Alga 300 K and Alga 600 on the root yield and digestion was evaluated. According to the methodology from the producer Agrobiosfer s.r.o. two applications were applied during the growing season of sugar beet in growth phases of BBCH 19 and BBCH 33. Biopreparations were applied by hand sprayer at dosages:

- Alga 300 P (1 l*ha^{-1}) + Alga 300 K (1l*ha^{-1})
- Alga 600 (0.5 kg*ha^{-1})

Statistical methods

For statistical – evaluation analysis of variance and Tukey contrast test of software Statistica 10 was used.

Results

Root yield

According statistical analysis, can be unequivocally confirm, that climate conditions in 2014 and 2015 had statistically high significant influence on root yield (Table 2). In 2014, was achieved higher root yield 88.67 t*ha^{-1}, what was about 29.2 t*ha^{-1} (rel. 32.93%) higher than in 2015. This big difference was caused by various weather conditions in each year and it was statistically significant (Table 3). Especially high rainfall at the end of growing season 2014 had a significant impact on the final root yield. To impact of weather conditions on root yield is currently dedicated big attention from various authors (Pačuta et al., 2003; Černý et al., 2006; Mahmoodi et al., 2008).

Table 2. Analysis of variance – Root yield in 2014 and 2015

Table 2. Analýza rozptylu – Úroda buliev v rokoch 2014 a 2015

Source of variability	RY (P – values)	Source of variability (interactions)	RY (P – values)
Year	0.0000**	Year*Variety	0.0003**
Variety	0.0945	Year*Biopreparation	0.2866
Biopreparation	0.0217*	Variety*Biopreparation	0.8339

** High significant influence; * Significant influence; RY Root yield

** Vysoko preukazný vplyv; * Preukazný vplyv; RY Úroda buliev

Table 3. Average values of root yield inside the year factor

Table 3. Priemerné hodnoty úrody buliev vo vnútri faktora ročník

Factor	RY (t*ha^{-1})	
Year	Average	HG
2014	88.67	b
2015	59.47	a

a, b Indices, which assessing significant influence based on Tukey test, α=0.05; HG Homogenous group; RY Root yield

a, b Indexy, ktoré indikujú preukazný rozdiel na základe Tukeyovho testu, α=0.05; HG Homogénna skupina; RY Úroda buliev

The influence of variety on root yield was non-significant (Table 2). The highest values achieved variety Kosmas 76.73 t*ha^{-1}, compared with the variety Galvani it was about 2.71 t*ha^{-1} (rel. 3.53%) more, with variety Kant about 3.93 t*ha^{-1} (rel.

5.12%) more and compared with variety Antek 3.99 t*ha^{-1} (rel. 5.20%) more. These differences in root yield of each variety were non-significant (Table 4).

Table 4. Average values of root yield inside factor variety

Table 4. Priemerné hodnoty úrody buliev vo vnútri faktora odroda

Factor Variety	RY (t*ha^{-1})	
	Average	HG
Antek	72.74	a
Kant	72.80	a
Galvani	74.02	a
Kosmas	76.73	a

a, b Indices, which assessing significant influence based on Tukey test, α=0.05; HG Homogenous group; RY Root yield

a, b Indexy, ktoré indikujú preukazný rozdiel na základe Tukeyovho testu, α=0.05; HG Homogénna skupina; RY Úroda buliev

Significant influence on yield formation had application of biopreparations Alga 300 P + Alga 300 K and Alga 600 compared with control treatment (Table 2). Control variant achieved root yield 72.66 t*ha^{-1}. After using combinations of preparations Alga 300 P + Alga 300 K, was recorded a slight increase about 0.29 t*ha^{-1} (rel. 0.40%), after application biopreparation Alga 600 was an increase 3.95 t*ha^{-1} (rel. 5.16%). The difference between control treatment and treatment with Alga 600 was significant (Table 5).

Table 5. Average values of root yield inside factor biopreparation

Table 5. Priemerné hodnoty úrody buliev vo vnútri faktora biopreparát

Factor Biopreparation	RY (t*ha^{-1})	
	Average	HG
Control	72.66	a
Alga 300 P + Alga 300 K	72.95	ab
Alga 600	76.61	b

a, b Indices, which assessing significant influence based on Tukey test, α=0.05; HG Homogenous group; RY Root yield

a, b Indexy, ktoré indikujú preukazný rozdiel na základe Tukeyovho testu, α=0.05; HG Homogénna skupina; RY Úroda buliev

High significant interaction of year and variety on root yield was noted. Other interactions were statistically non-significant (Table 2).

A positive impact of biopreparations on root yield confirmed a lot of authors (Candráková et al., 2009; Pačuta et al., 2015; Pusenkova et al., 2015).

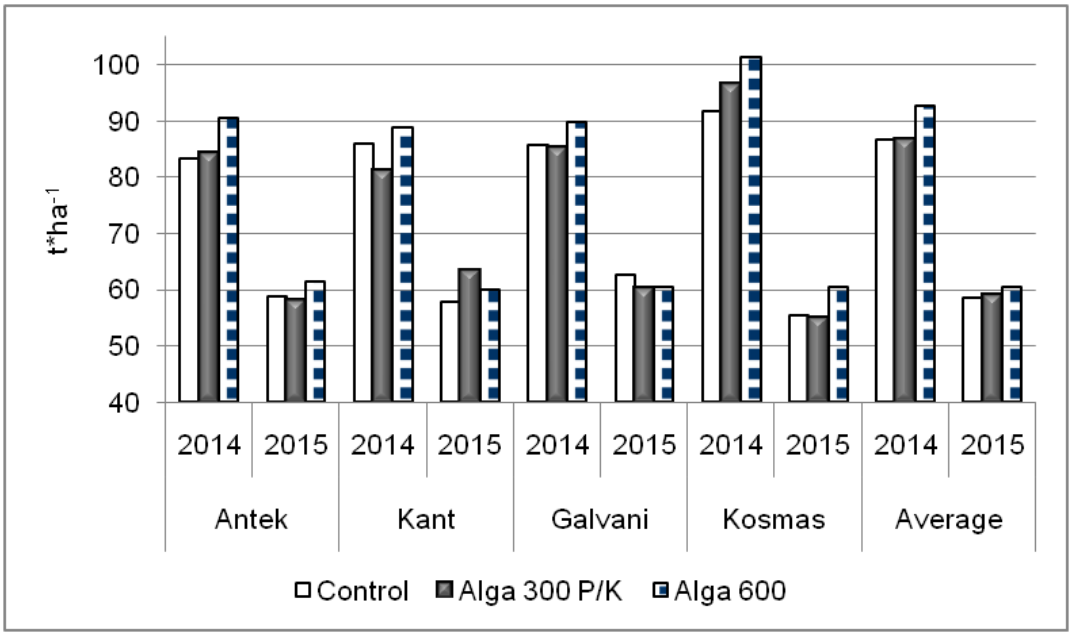


Figure 3. Root yield in 2014 and 2015

Figure 3. Úroda buliev rokoch 2014 a 2015

Digestion

The weather condition in 2014 and 2015 had statistically high significant influence on digestion (Table 6).

Table 6. Analysis of variance – Digestion in 2014 and 2015

Table 6. Analýza rozptylu – Digescia v rokoch 2014 a 2015

Source of variability	Dg (P – values)	Source of variability (interactions)	Dg (P – values)
Year	0.0000**	Year*Variety	0.0001**
Variety	0.0000**	Year*Biopreparation	0.0000**
Biopreparation	0.5093	Variety*Biopreparation	0.0215*

** High significant influence; * Significant influence; Dg Digestion

** Vysoko preukazný vplyv; * Preukazný vplyv; Dg Digescia

Production parameters of sugar beet are influenced by many factors (variety, weather conditions and also fertilization). Digestion parameter is higher in such conditions, which allowing longer growing season thanks to good weather conditions (Asadi, 2006).

Table 7. Average values of digestion inside the year factor

Table 7. Priemerné hodnoty digescie vo vnútri faktora ročník

Factor	Dg (°S)	
Year	Average	HG
2014	16.26	a
2015	17.67	b

a, b Indices, which assessing significant influence based on Tukey test, α=0.05; HG Homogenous group; Dg Digestion

a, b Indexy, ktoré indikujú preukazný rozdiel na základe Tukeyovho testu, α=0.05; HG Homogénna skupina; Dg Digescia

High significant influence on digestion had factor variety (Table 6). The best results were achieved in a variety Galvani, whose digestion reached 17.49 °S. Compared to the variety Antek it was about 0.29 °S (rel. 1.66%) more, compare to variety Kant about 0.83 °S (rel. 4.75%) more and compared with variety Kosmas about 0.96 °S (rel. 5.49%) more. Non-significant differences were found between varieties Kant and Kosmas, comparisons between other varieties were statistically significant (Table 8).

Table 8. Average values of digestion inside factor variety

Table 8. Priemerné hodnoty digescie vo vnútri faktora odroda

Factor	Dg (°S)	
Variety	Average	HG
Antek	17.20	b
Kant	16.66	a
Galvani	17.49	c
Kosmas	16.53	a

a, b, c Indices, which assessing significant influence based on Tukey test, α=0.05; HG Homogenous group; Dg Digestion

a, b, c Indexy, ktoré indikujú preukazný rozdiel na základe Tukeyovho testu, α=0.05; HG Homogénna skupina; Dg Digescia

The use of biopreparation had non-significant influence on the digestion value (Table 6). The best results were obtained on the control treatment 17.01 °S, what was about 0.02 °S more compared with variant Alga 300 P + Alga 300 K and about 0.10 °S more compared with variant Alga 600 and differences were non-significant (Table 9).

Table 9. Average values of digestion inside factor biopreparation

Table 9. Priemerné hodnoty digescie vo vnútri faktora biopreparát

Factor Biopreparation	Dg (°S)	
	Average	HG
Control	17.01	a
Alga 300 P + Alga 300 K	16.99	a
Alga 600	16.91	a

a, b Indices, which assessing significant influence based on Tukey test, α=0.05; HG Homogenous group; Dg Digestion

a, b Indexy, ktoré indikujú preukazný rozdiel na základe Tukeyovho testu, α=0.05; HG Homogénna skupina; Dg Digescia

Statistically high significant were interactions as follows: year*variety and year*biopreparation on digestion parameter. Variety*biopreparation interaction was significant (Table 6). The best result from the interaction point of view achieved variety Galvani in 2015 with application of biopreparation Alga 600 (Figure 4).

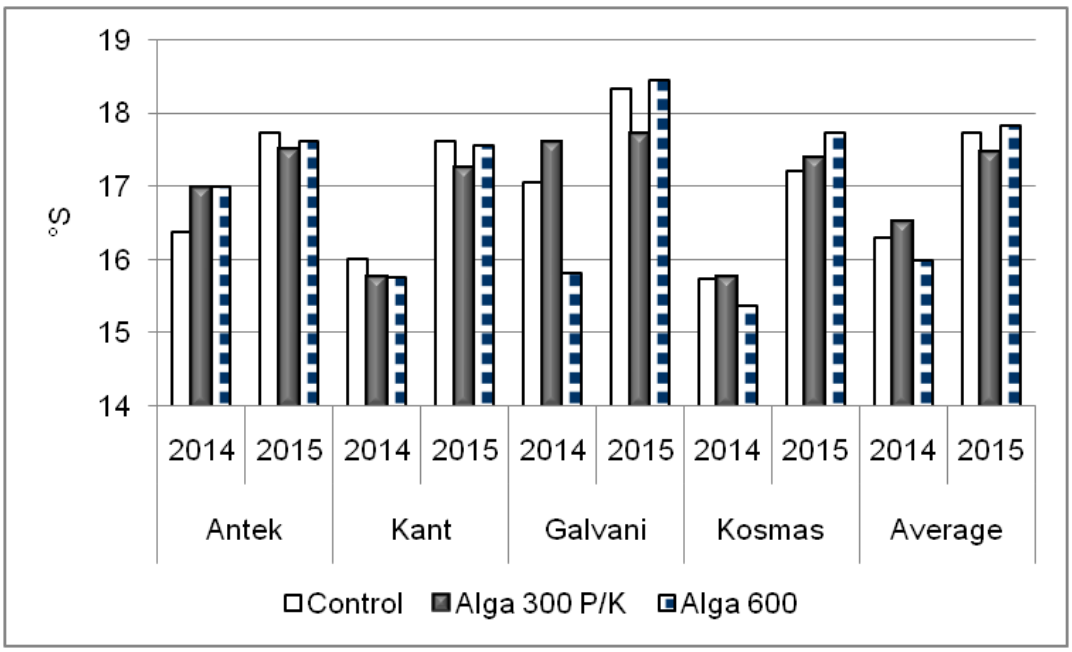


Figure 4. Digestion in 2014 and 2015

Figure 4. Digescia v rokoch 2014 a 2015

Conclusions

On the basis of experiment results, which were reached in 2014 and 2015, can be state these conclusions:

- weather conditions had high significant influence on root yield and digestion,
- variety had high significant influence only on digestion,
- biopreparation had significant influence on root yield.

This topic has on the present big justification because of ongoing climate changes. Selection the proper agrotechnical measures helps to overcome weather fluctuations and provide a stable yield.

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