CHANGES IN BETAINE CONTENT IN SELECTED CULTIVARS OF SUGAR BEET TREATED WITH BIOLOGICALLY ACTIVE COMPOUNDS

V. Švachula[1], J. Pulkrábek[1], J. Zahradníček[2]

[1] *Czech University of Agriculture, Faculty of Agronomy, Prague, Czech Republic*

[2] *VUC, a.s., Research Institute of Sugar Industry, Prague, Czech Republic*

The influence of foliar application of biologically active compounds (commercial growth regulators Rastim and Atonik and synthetic cytokinin N^6-(*meta*--hydroxybenzyl)-adenosine and bioalginate on the betaine content in leaves and roots in six sugar beet cultivars was examined. The experiments were realized at the Experimental Station of the Czech University of Agriculture in Prague on small plots with regard to the weather of different years 1993, 1994, 1995. The first spray was made before full canopy closing and the second 6 weeks before harvest. The mean betaine content in per cent of dry matter of leaf blades was in studied variants 3.44 in 1993, 5.73 in 1994 and 4.67 in 1995. The betaine content in per cent of dry matter of roots as the mean of all variants was 2.18 in 1993, 1.77 in 1994 and 1.93 in 1995. The differences in betaine content among the cultivars were higher in comparison with the differences of variants with different application of biologically active compounds and in the main at the limit of significance. The highest decrease of betaine in leaves and roots was in 1993 after foliar spray of Atonik and in 1994 after spring foliar spray of cytokinin. The betaine content increased in Hilma cultivar leaves in 1995, after spraying of growth compounds and the greatest decrease after the treatment, was in Ibis and Edda cultivars. The effect of biologically active compounds showed lower values in standard variations, variance and high percentage of stability rate every year. A negative correlation of leaf and root yields on the betaine level in blades and roots was proved in 1993. In the other years this association was less visible and the trend was reverse. Changes in betaine content after application of biologically active compounds depend very much on meteorological conditions and in leaves mainly on the precipitation in April and in roots more on the precipitation distribution in the second half of vegetation period.

sugar-beet; betaine; biologically active compounds; influence of precipitation; influence of cultivars

INTRODUCTION

One of the most effective nitrogen compound in sugar beet is the betaine or trimethylderivate of glycine $(CH_3)_3N^+CH_2COO^-$, with molecular weight 117.146 and N content of 11.05 % (Bretschneider et al., 1974).

Starting point for betain biogenesis is an oxidative saccharide exchange, when alpha-ketoglutaric acid, originating in Krebs cycle enables a conversion to amino acid metabolism. Betaine probably originates by a direct methylation of amino acid glycine, with the transfer of methyl groups through tetrahydrofolic acid translocation (Delwiche, Bregoff, 1958; Steinmetzer, 1972).

In sugar beet ontogenesis betaine plays a very important role, the biochemical and physiological function of which is still not very enlightened betaine (Cromwell, Rennie, 1953,1954; Delwiche, Bregoff, 1958; Steinmetzer, 1972; Wyn Jones, 1980; Jefferies, 1980; Saxton et al., 1980; Švachula, 1981), except its importance as a component of the so-called harmful nitrogen, for it passes to molasses during the sugar refining processing (Sommer, 1957). Relatively high betaine concentration in plant tissues is the taxonomic character main by in the species from the family *Chenopodiaceae* and *Amaranthaceae* (Staněk, Domin, 1909; Wyn Jones, 1980; Jefferies, 1980). Betaine stimulates in some plants the accumulation of dry matter and chlorophyll and its positive effect was proved in frost resistance, for example in potatoes (Bokarev, Ivanova, 1971). The noteworthy is the correlation of betaine content in sugar beet and NaCl stress and mainly diseases resistance (Cromwell, Rennie, 1953, 1954; Steinmetzer, 1972; Storey, Wyn Jones, 1975; Rains et al., 1980; Jefferies, 1980; Wyn Jones, 1980; Hanson, Wyse, 1982). Betaine is not a waste product or a compound of ammonium detoxication, but a molecule with a distinct physiological function in osmotic adaptation (Rains et al., 1980; Jefferies et al., 1980; Saxton et al., 1980). Betaine increases pathogene resistance (bacteria and viruses) from 40–45% by means of special antiphytopathogenic system cholin-cholindehydrogenase-betaine (Sokolova et al., 1967). Many authors have studied the localisation and dynamics of betaine from the beginning of this century till now (e.g. Staněk, Domin, 1909; Cromwell, Rennie, 1953, 1954, Delwiche, Bregoff, 1958; Steinmetzer, 1972; Bretschneider et al., 1974; Hanson, Wyse, 1982; Beiss, 1994; Švachula, 1979; Švachula, Pulkrábek, 1995). They conform with the fact, that the betaine content is higher in leaves than in roots and the leave content is increasing in leaves during ontogenesis (in contrast to free amino acids and amides) and is decreasing in roots. In the first vegetation period betaine is transported to the leaves from the root system, its content is higher in younger leaves and lower during their withering. Betaine creates an increasing gradient inside the sugar beet head inside the beet root. The minimum content of betaine is not connected with maximum root and refined sugar yield, but more with medium content, so in the way of optimum content. Betaine content differs in individual cultivars. It was also proved, that betaine formation is inhibited by the oxygen absence and is usually higher in the light than in dark conditions. Betaine content in roots can be increased in a delayed harvest.

Saccharides and proteins are of reserve compounds character in sugar beet, amides and betaine present structural and transport compounds and can be found anywhere in plants, where new tissues are built (Stehlík, 1982). This characterization was a motivation for betaine utilization, besides the basic technological values, for finding and explanation of biologically active compound influences, mainly of cytokinin on the yield and sugar beet quality (Zahradníček, 1993; Pulkrábek, 1995). The spray of sugar beet leaves by N^6-(*m*-hydroxybenzyl)-adenosine affects, according to the present studies, respiration and membrane transport processes (Kotyk et al., 1996) and an increase of net photosynthesis and photorespiration slows down the plant senescence (Čatský et al., 1996; Zahradníček et al., 1995).

MATERIAL AND METHODS

Field experiments: Small plot experiments were established at Experimental Station of Crop Science Department, Faculty of Agronomy, Czech University of Agriculture, on deep orthic luvisol soils with a common growing technology. Experimental sugar beet plots of the size 8.4 x 3.1 m were sown in 50 cm rows and the plant distance within the rows was 4–6 cm, in 4 replicates. The plants were thinned after the plant emergency.

Six cultivars were involved in field experiments, 3 high in sugar content from Germany (Ibis, Edda, Perla) and 3 cultivars from Hilleshög (Sweden – CR) – Jitka (high yielding type), Petra (normal till sugary type) and Hilma (normal till sugary type).

After fully developed canopy and 6 weeks before harvest the regulators Rastim 30 DKV (0,3 $l.ha^{-1}$, dispersable concentrate water diluted, active compound benzothiazoline, containing 300 g of active compound per 1 litre, produced by Istrochem Bratislava, Slovak Republic), were applied Atonik (0,6 $l.ha^{-1}$; active substances are aromatic nitrocompounds, manufactured by Japan – ASAHI CHEMICAL MFG. Co. Ltd.), synthetic cytokinin N^6-(*meta*-hydroxybenzyl)-adenosine (concentration 3.10^{-6} mol in 300 l water per hectare) and Bioalgeen S 90 (3,0 $l.ha^{-1}$, hydrolysate from sea algae).

In 1993 vegetation period followed May normal in precipitation and very warm after very dry and warm April. June, July and September were of humid character and September was very cold. August was normal in precipitation and temperature. The 1994 vegetation period was strongly below normal in precipitation and with above normal temperatures in June. In July, the precipitation was below normal and temperatures above normal. August was above normal in both parametres and caused a strong retrovegetation of beet plants during the second half of vegetation period. In 1995 vegetation period were May and June above normal in precipitation (unequally emerged plants were affected by hypoxy), but in contrary June was below normal in temperature. Extreme, above normal temperatures were observed in July and August. The other months can be characterized as normal in precipitation and air temperature.

Plant material for betaine determination was sampled before the harvest of experimental plots. The samples from single replicates were mixed together after drying and then ground before analyses.

Betaine content was determined by modified method (Bretschneider et al., 1968; Lukovnikova, Jaroš, 1972; Prey et al., 1974) consisting in betaine precipitation in water extract from dry samples of plant material by means of Reinecke salt (tetrarhodano-diamo-ammonium chromitane) $NH_4[Cr(NH_3)_2(SCN)_4]$ with following measurement of arosen colour solution on Spekol-220 Spectrophotometer (Carl Zeiss Jena) – wave length 525 nm (Švachula, Kohout, 1977; Švachula, 1979, 1981; Švachula et al., 1995).

RESULTS

The mean betaine content in leaf blades in all observed variants was the highest in 1994 and in roots in 1993. The three years mean of betaine content in blades was roughly 2.4 times higher than in roots (Tab. I).

Analyses among others showed, that the influence of cultivars in betaine content is more evident, than the influence of biologically active compounds

I. Mean betaine content (% dry matter) in leaves and roots of sugar beet in all studied variants

Growing organ	1993	1994	1995	Average
Leaf blades	3.44	5.73	4.67	4.613
Roots	2.18	1.77	1.93	1.960
Value how many times is the content higher in blades than in roots	1.6	3.4	2.4	2.35

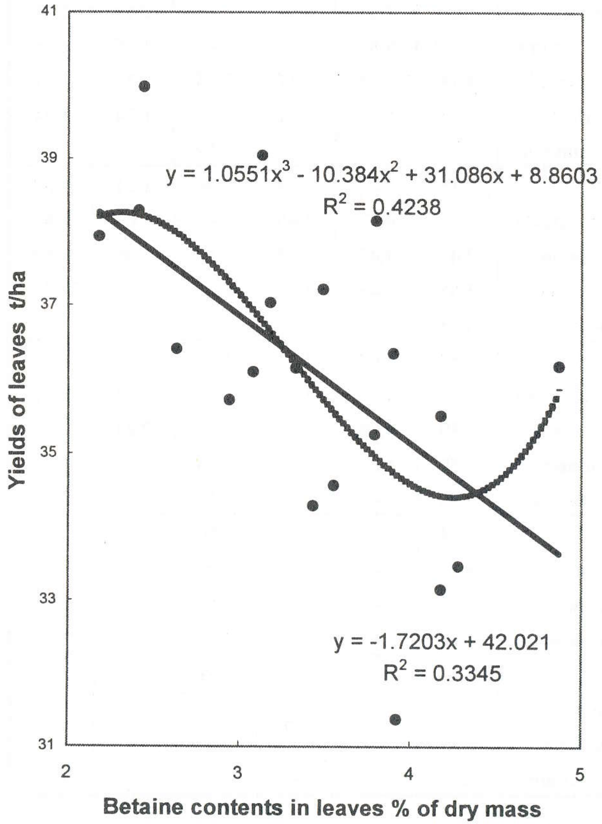
II. Betaine content in dry samples of sugar beet before harvest – Experimental station Prague-Uhříněves

Cultivar	Variant	Leaves			Roots		
		1993	1994	1995	1993	1994	1995
Hilma	Check	–	6.40	3.62	–	1.69	1.23
	Cytokinin spring	–	6.16	5.26	–	1.97	1.55
	Cytokinin autumn	–	5.49	5.31	–	1.68	1.78
	Cytokinin spring + autumn	–	5.83	5.29	–	1.89	2.28
	Atonik spring + autumn	–	5.57	5.94	–	1.62	1.89
	Rastim spring + autumn	–	6.04	5.92	–	1.82	2.46
Edda	Check	3.92	8.29	6.26	2.43	1.74	2.22
	Cytokinin spring	–	7.04	4.20	–	1.98	2.24
	Cytokinin autumn	–	7.23	7.58	–	2.13	2.43
	Cytokinin spring + autumn	–	5.87	6.33	–	1.95	2.28
	Atonik spring + autumn	4.18	7.15	4.17	2.15	1.33	1.91
	Rastim spring + autumn	3.43	5.53	3.81	2.11	1.74	1.44
	Bioalgen spring + autumn	4.28	–	–	2.19	–	–
Ibis	Check	2.18	5.07	3.69	1.30	1.51	1.89
	Cytokinin spring + autumn	–	4.97	3.66	–	1.65	1.65
	Atonik spring + autumn	2.41	4.42	2.95	1.58	1.45	1.58
	Rastim spring + autumn	3.55	5.48	4.02	1.25	1.58	1.75
	Bioalgen spring + autumn	3.18	–	–	1.34	–	–
Petra	Check	4.87	3.62	3.33	3.06	1.65	1.69
	Cytokinin spring + autumn	–	4.01	3.39	–	1.93	2.31
	Atonik spring + autumn	3.80	4.89	4.98	2.60	2.23	2.01
	Rastim spring + autumn	3.79	5.61	3.61	2.64	1.95	1.91
	Bioalgen spring + autumn	3.08	–	–	3.11	–	–
Perla	Check	2.94	–	–	2.80	–	–
	Atonik spring + autumn	3.13	–	–	1.98	–	–
	Rastim spring + autumn	3.90	–	–	2.59	–	–
	Bioalgen spring + autumn	4.18	–	–	2.00	–	–
Jitka	Check	3.33	–	–	2.11	–	–
	Atonik spring + autumn	2.44	–	–	2.16	–	–
	Rastim spring + autumn	3.49	–	–	2.00	–	–
	Bioalgen spring + autumn	2.63	–	–	2.19	–	–

Note: dash = data were not measured

(Tab. II, III, IV). The highest level of betaine in leaves and partly in roots were observed in cultivars Hilma and Edda and the lowest (positive for technology) in blades and roots of cv. Ibis and Jitka.

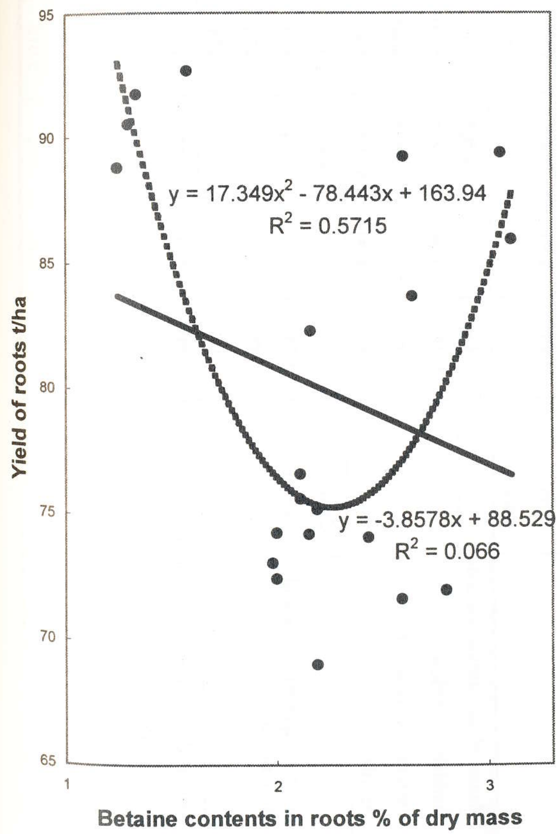
The effect of biologically active compounds on the betaine content was mostly insignificant in given experimental conditions. Only certain tendences were evident (Tab. III, IV). The betaine content in leaves and roots decreased on average in 1993 after the application of biologically active compounds (mainly in the Atonic variant). The growth compounds had a reverse effect in 1994, caused by the influence of retrovegetation and the most perspicuous increase was evident after cytokinin application. The increase of betaine content in leaves and roots of cv. Hilma and Petra came in 1995. The other cultivars were not ambiguous in differences.



1. Dependence of leaf yields (t.ha^{-1}) on betaine content in leaves (% of dry mass) – sugar beet at Experimental Station Prague-Uhříněves; full line = linear regression, broken line = polynomic regression

The effect of growth compounds showed lower levels in standard deviations and variance with a high percentage of stability rate in all the experimental years (Tab. III).

It was possible to observe the relationship between the betaine level in blades and roots at the harvest and final leave and root yields by regressive analysis of obtained values by the help of computer program Microsoft Excel 5.0 (Tab. V). Relative high levels of confidence regressive coefficient show the significance of this relationships (Tab. V, Fig. 1, 2). These tendencies were not proved in 1994 and 1995. The higher correlation coefficient of polynomic curve (towards linear) indicated in all experimental years, that the highest yields had, as a rule, the extreme betaine content (high or low) and the lowest yields had more often average betaine levels.



2. Dependence of root yields (t.ha^{-1}) on betaine content in roots (% of dry mass) – sugar beet at Experimental Station Prague-Uhříněves; full line = linear regression, broken line = polynomic regression

III. Mean betaine content in sugar beet leaves and roots before harvest (% of dry matter)

Cultivars Application of biol. act. comp. Check variants		Blades				Roots			
		1993	1994	1995	average	1993	1994	1995	average
Cultivar means (treated + checks)	Hilma	–	5.92	5.22	5.570	–	1.79	1.87	1.830
	Ibis	2.83	4.99	3.58	3.800	1.37	1.55	1.72	1.547
	Edda	3.95	6.85	5.39	5.397	2.22	1.81	2.09	2.040
	Perla	3.54	–	–	3.540	2.34	–	–	2.340
	Petra	3.89	4.53	3.83	4.083	2.85	1.97	1.98	2.257
	Jitka	2.97	–	–	2.970	2.12	–	–	2.120
Means of all cultivar variants		3.436	5.573	4.505	4.505	2.180	1.780	1.925	1.958
Standard deviation		0.462	0.891	0.807	0.7201	0.477	0.150	0.137	0.2545
Variance of basic set		0.231	0.795	0.651	0.9045	0.227	0.023	0.019	0.0723
Stability rate %		86.56	84.00	82.08	77.490	78.14	91.57	92.85	86.750
Mean of applied compound (all cultivars)	Cytokinin	–	5.17	4.67	4.920	–	1.86	2.13	1.995
	Rastim	3.63	6.67	4.34	4.880	2.12	1.77	1.89	1.927
	Bioalgen	3.47	–	–	3.470	2.17	–	2.170	–
	Atonik	3.19	5.51	4.51	4.403	2.09	1.66	1.85	1.867
Means of all variants of applied compounds		3.430	5.783	4.507	4.573	2.127	1.763	1.957	1.949
Standard deviation		0.182	0.642	0.135	0.3196	0.033	0.082	0.124	0.0795
Variance of basic set		0.033	0.412	0.018	0.3411	0.001	0.007	0.015	0.0129
Stability rate %		94.70	88.90	97.01	86.780	98.45	95.36	93.68	94.340
Check variants	Hilma	–	6.40	3.62	5.010	–	1.69	1.23	1.460

Continuation of Tab. III

Cultivars Application of biol. act. comp. Check variants		Blades				Roots			
		1993	1994	1995	average	1993	1994	1995	average
Check variants	Ibis	2.18	5.07	3.69	3.647	1.30	1.51	1.89	1.567
	Edda	3.92	8.29	6.26	6.157	2.43	1.74	2.22	2.130
	Perla	2.94	–	–	2.940	2.80	–	–	2.800
	Petra	4.87	3.62	3.33	3.940	3.06	1.65	1.69	2.133
	Jitka	3.33	–	–	3.330	2.11	–	–	2.110
Means of all check variants		3.448	5.845	4.225	4.506	2.340	1.648	1.758	1.915
Standard deviation		0.908	1.720	1.183	1.270	0.612	0.086	0.359	0.3520
Variance of basic set		0.835	2.959	1.399	1.200	0.375	0.007	0.129	0.1932
Stability rate %		73.66	70.57	72.01	73.73	71.97	94.81	79.60	78.42

Note: dash = data were not measured

IV. Bifactorial analysis of variance (without replicates) of betaine content in sugar beet

Year	Factor	Leaf blades				Roots			
		Alfa	$F_{calc.}$	$F_{critic.}$	significance	Alfa	$F_{calc.}$	$F_{critic.}$	significance
1993	cultivars	0,10	2,723	2,480	**	0,05	19,635	3,259	***
	biol. act. comp.	0,10	0,425	2,606	–	0,05	1,059	3,490	–
1994	cultivars	0,05	4,822	3,863	***	0,10	2,983	2,813	**
	biol. act. comp.	0,05	0,414	3,863	–	0,10	1,104	2,813	–
1995	cultivars	0,20	2,048	1,901	*	0,05	0,446	3,863	–
	biol. act. comp.	0,20	0,157	1,901	–	0,05	0,710	3,863	–

V. Dependence of leaves and roots yields of sugar beet ($t.ha^{-1}$) on the betaine content in leaves and roots (% of dry mass) – values of confidence of regression equations R and tendency of curves

Year	Leaves		Roots	
	linear regression	regression polynom of 3rd degree	linear regression	regression polynom of 3rd degree
1993	0.58 decreasing	0.65 decreasing	0.26 decreasing	0.76 decreasing
1994	0.03 sligtly increasing	0.54 sligtly increasing	0.06 sligtly increasing	0.30 sligtly increasing
1995	0.48 increasing	0.60 increasing	0.35 increasing	0.47 increasing

A significant influence on the effect of growth compound application, even on the cultivar yields, had the weather character of experimental vegetation, mainly precipitation and temperature distribution. The values of significance (correlation coefficients) of regressive equations of the dependence of betaine content in experimental variants on the sum of precipitation in individual months support this reality (Tab. VI).

The closest dependence of the final betaine content in leaves on the precipitation was in April and August. In roots came this dependence in April precipitation but only in variants treated with growth compounds. The closest relationship to precipitation in cultivars was in the second half of the vegetation period.

VI. Dependence of betaine content on the sum of month precipitation – correlation coefficients of regression equations ranged decliningly

Plant part	Cultivar means		Means after application of biol. activ. compounds		Check variants	
	R^2	month	R^2	month	R^2	month
Leaves	0.9988	IV	0.9932	IV	0.9463	IV
	0.9984	VIII	0.9923	VIII	0.9438	VIII
	0.9604	VII	0.9394	VII	0.8483	VII
	0.9275	IX	0.9004	IX	0.7930	IX
	0.5052	VI	0.5535	VI	0.6992	VI
	0.1139	V	0.0850	V	0.0208	V
Roots	0.9998	VII	0.9953	IV	0.9894	IX
	0.9925	IX	0.9945	VIII	0.9695	VII
	0.9787	VIII	0.9459	VII	0.8911	VIII
	0.9771	IV	0.9086	IX	0.8876	IV
	0.3230	VI	0.5396	VI	0.4350	V
	0.2559	V	0.0930	V	0.1623	VI

DISCUSSION

The presented results show, that the betaine content could be utilized not only as one of the criteria of ecological influences, but also as an indicator of the activity or inactivity of biologically active compound application. The knowledge about the betaine accumulation in sugar beet gives the possibility of a wider exploitation, for example in fodder or pharmaceutical industry and so sugar beet could be considered as a fodder or energetic crop (Steinmetzer, 1972; Bretschneider et al., 1974).

The results observed correspond with the data in literature (Sommer, 1957; Prey et al., 1974; Hanson, Wyse, 1982). No significant relations were proved among betaine and other technological characters, mainly yield (Beiss, 1994). More considerable differences among cultivars were observed. It testifies, that the cultivars are in the possession of a higher sensitiveness to growth compounds. Their application will be economical mainly in cultivars which are sensitive and reactive (Zahradníček, 1993; Pulkrábek, 1995).

Our previous knowledge was confirmed in the practice, showing that the betaine content is not connected with maximal yields. Medium content of betaine appears to be optimum in root yields (Švachula, 1978). Our results proved, that the betaine accumulation is often connected with a stress (Wyn Jones, 1980; Saxton et al., 1980) and that the betaine keeps a significant physiological function in the osmotical adaptability to environmental conditions (Rains et al., 1980). It could be very interesting to study changes in betaine dynamics during ontogenesis and mainly immediately after the application of biologically active compounds. This could be a theme for a further research work.

The high betaine levels in leaf blades (in 1994) prove the fact, that betaine is a structural and transport compound, evidently as a consequence of retrovegetation (Cromwell, Rennie, 1953, 1954; Delwiche, Bregoff, 1958; Stehlík, 1982; Beiss, 1994).

The weather of all experimental years was rather extreme and thus was the positive influence of biologically active compounds to a certain extent lower (Zahradníček et al., 1995; Kotyk et al., 1996; Čatský et al., 1996). Nevertheless, the study confirmed, that betaine is a sensitive indicator not only for weather conditions but for growing technology too (Zahradníček, 1993; Pulkrábek, 1995). The changes in betaine content can contribute together with other technological properties to a revelation of the effect of biologically active compounds and to the process of their application and also define with more precision the methods of its exploitation.

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ŠVACHULA, V. – PULKRÁBEK, J. – ZAHRADNÍČEK, J. (Česká zemědělská univerzita, Agronomická fakulta, Praha; VUC a.s., Výzkumný ústav cukrovarnický, Praha, Česká republika):

Změny obsahu betainu ve vybraných odrůdách cukrovky ošetřené biologicky aktivními látkami.

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V povětrnostně rozdílných ročnících 1993, 1994 a 1995 byl na maloparcelových pokusech České zemědělské univerzity v Praze (Pokusná stanice v Praze-Uhříněvsi) zkoumán vliv listové aplikace biologicky aktivních látek – komerčních růstových regulátorů Rastim a Atonik, syntetického cytokininu N^6-(*meta*-hydroxybenzyl)-adenosinu a bioalginátu – na obsah betainu v listech a bulvách šesti odrůd cukrovky. První postřik se uskutečnil po zapojení porostu a druhý šest týdnů před sklizní. Průměrný obsah betainu v procentech sušiny listových čepelí u zkoumaných variant byl 3,44 v roce 1993, 5,73 v roce 1994 a 4,67 v roce 1995. Bulvy měly v průměru všech variant obsah betainu v procentech sušiny 2,18 v roce 1993, 1,77 v roce 1994 a 1,93 v roce 1995. Průměrný obsah betainu v listových čepelích všech sledovaných variant byl nejvyšší v roce 1994 a v bulvách v roce 1993. Obsah betainu v listových čepelích byl v průměru tří let zhruba 2,4krát vyšší než v bulvách (tab. I).

Analýzy ukázaly, že vliv odrůd se v obsahu betainu projevil zřetelněji než vliv biologicky aktivních látek (tab. II, III a IV). Nejvyšší hladinu betainu v listech a zčásti i v bulvách vykázaly odrůdy Hilma a Edda a nejnižší (technologicky příznivou) v čepelích i v bulvách odrůdy Ibis a Jitka.

Účinek biologicky aktivních látek na obsah betainu byl v daných pokusných podmínkách většinou neprůkazný. Patrné byly pouze určité tendence (tab. III a IV). V roce 1993 obsah betainu v listech i bulvách po aplikaci biologicky aktivních látek v průměru poklesl (nejvíce u varianty s Atonikem) a v roce 1994 vlivem retrovegetace působily růstové látky spíše opačně, přičemž nejzřetelnější zvýšení v listech i bulvách se projevilo po aplikaci cytokininu. V roce 1995 se účinkem růstových látek v listech i bulvách zvýšil obsahu betainu u odrůd Hilma a Petra. U ostatních odrůd nebyly změny jednoznačné.

Vliv aplikace biologicky aktivních látek se ve všech ročnících projevil nižšími hodnotami směrodatných odchylek a rozptylu a vysokým procentem míry stability (tab. III). Regresní analýzou souboru získaných hodnot bylo možné zachytit vztahy mezi hladinou betainu v čepelích a bulvách při sklizni a konečným výnosem chrástu a bulev (tab. V). Z regresních křivek roku 1993 vyplynulo, že čím byl vyšší výnos, tím nižší byl obsah betainu. Relativně vysoké hodnoty spolehlivosti – regresního koeficientu – svědčí o průkaznosti tohoto vztahu (tab. V, obr. 1 a 2). V letech 1994 a 1995 se tyto tendence nepotvrdily. Ve všech zkoumaných letech vyšší korelační koeficient polynomické křivky (proti lineárním) naznačil, že nejvyšší výnosy měly zpravidla rostliny s extrémními obsahy betainu (vysoké či nízké) a nejnižší výnosy měly spíše rostliny s průměrnými hladinami betainu.

Významný vliv na účinnost aplikace růstových látek i na výnosnost odrůd měl povětrnostní charakter pokusné vegetace, zvláště rozdělení srážek a teplot. Dokládají to hodnoty spolehlivosti (korelační koeficienty) regresních rovnic závislosti obsahu betainu v pokusných variantách cukrovky na úhrnu srážek v jednotlivých měsících (tab. VI).

U listů byla nejtěsnější závislost konečného obsahu betainu na srážkách v měsících dubnu a srpnu. U bulev byla nejtěsnější závislost na dubnových srážkách jen u variant ošetřených růstovými látkami, u odrůd byl nejtěsnější vztah ke srážkám v měsících druhé poloviny vegetace.

Všechny pokusné roky byly povětrnostně spíše extrémní, takže pozitivní vliv biologicky aktivních látek byl do jisté míry snižován. I tak však zkoumání obsahů betainu potvrdilo, že tato látka je citlivým indikátorem nejen povětrnostních vlivů, ale i pěstitelských zásahů. V komplexu s ostatními technologickými ukazateli mohou změny obsahu betainu přispět k objasnění účinku biologicky aktivních látek a způsobu jejich aplikace a v neposlední řadě umožní zpřesňování metod jejich použití.

cukrovka; betain; biologicky aktivní látky; vliv odrůd; vliv srážek

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Contact Address:

Prof. Ing. Vladimír Švachula, DrSc., Česká zemědělská univerzita, Agronomická fakulta, Kamýcká 129, 165 21 Praha 6-Suchdol, Česká republika, tel.: 02/24 38 25 35, fax: 02/34 44 18
