YIELD AND QUALITY OF SUGAR BEET AFTER FOLIAR FEEDING

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ABSTRACT

The effect of foliar feeding on yield and technological quality of sugar beet was studied on the basis of small plot field experiments. The experiment consisted of 24 variants, each treated with different fertilizer. This article discusses only a selection of harvest results, the whole experiment, however, covers development of sugar beet during the entire vegetation. At the harvest, 10 beet samples of each variant were taken. Roots and tops were weighed and then transported to the laboratory for subsequent laboratory analysis. Based on the results of these parameters yield of roots, yield of tops, sugar content and sugar content in molasses were assessed. The highest root yield was achieved with application of Fertiacyl Starter (131 $t.ha^{-1}$). The highest production of tops was observed with application of Glukorapid (44 $t.ha^{-1}$). Record sugar content – more than 20% – was achieved with application of Elitic (70) + Thiotrac. The lowest losses of sugar in molasses 1.27% were detected with the variants treated with Glukorapid.

Key words: sugar beet, yield, root, tops, sugar content

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INTRODUCTION

By controlled feeding of the sugar beet we may influence weight, sugar content and the ratio between the weight of roots and tops. Sugar beet requires medium-heavy loam soil, deep and neutral to slightly alkaline soil reaction (pH = 6.3 to 7.4). It is mainly potassium and nitrogen that sugar beet takes in largest quantities from the soil. Nutrient levels decrease throughout the vegetation. This is caused by the use of nutrients by the sugar beet for biomass production; the biomass therefore dilutes the nutrients. An average sugar beet uses K 5.6 kg, N 4.4 kg, Ca 2 kg, Na 0.9 kg, Mg 0.8 kg and P 0.7 kg per 1 ton of roots. Particularly at the beginning of vegetation, intake of easily accessible nutrients (especially phosphorus) is significant. Thus any deficiency of nutrients can be also tackled by foliar feeding (Richter, Hřivna, 2001). Plants can take in nutrients through all their organs, including leaves. An important prerequisite for the functioning of individual nutrients is that the solution targets the greatest possible area for as long as possible. It should be noted that the foliar feeding cannot replace the root feeding. It functions rather as a "nutritional supplement" or a measure to eliminate adverse conditions such as unsuitable soil conditions, damage to roots, or to overcome the critical growth periods (Vaněk et al., 2002).

MATERIAL AND METHODS

Small plot field trial – in which the effects of foliar feeding and those of selected anti-stressors on change of the sugar beet quality were tested – was based on the plot of land belonging to the area of ZP Agrospol Velká Bystřice. The experiment was commenced on 30 May 2012. The land is located in a region with moderately warm and moderately humid climate. The soil is medium-heavy, brown earth soil type. Description of the area including the basic agronomic characteristics is given below:

Area: Velká Bystřice

Plot of land: U chmelnice

Cultivar: Imperial

Previous crop: winter wheat (plowed straw)/straw – 3 t/ha Betaliq (N 2-3%, K_2O 5%)

Date of sowing: 24. March 2012

Sowing rate: 1.17 kg/ha, final distance 19.9 cm between rows 0.45 m

Harvest took place on 5 March 2012. In total, 24 variants were harvested; ten sugar beet plants of each were taken for samples. Then the weight of tops and roots were established. The sugar content of the roots was determined along with the content of soluble ash and α-amino nitrogen. Sugar content was determined using POLAMAT–S, establishment of the ash content in the beets was performed on the conductivity meter Inolab Level 1 WTW. The value of α-amino nitrogen was determined on the spectrophotometer Konica Minolta CM 3500d. Samples for the analyses were prepared according to methods set forth in Friml, Tichá (1986). Based on the results obtained at each sampling, the proportion of sugar in molasses (PCM) was established. The method of calculation is given below:

PCM: PCM = 0,12 . (cNa + cK) + 0,24 . cN + 0,48
Explanation: cNA – sodium concentration in mmol/100g of beet
cK – potassium concentration in mmol/100g of beet
cN – α-amino nitrogen concentration in mmol/100g of beet

The experiment consisted of three parts which differed from each other in application dates of the preparation on each product and therefore separate controls are carried out. However, for clarity reasons, the evaluation of individual variants was carried out together. Overview of the basic variants is shown in Table 1, including colour differentiation of the individual parts. Each variant was divided into two equally large growing plots: 1st with one application of fertilizer/elicitor (1 application date) and 2nd with two applications (1 and 2 application date). At the same time, ½ growing area was always treated with fungicide. Each variant thus consisted of 4 sub-variants. To further assess the effect of fertilizers and elicitors, statistical analysis of the data was performed while each sub-variant served as repetition, i.e. the number of applications of the preparation was not taken into account neither was the fact whether the plant had been treated with fungicides. The basis was therefore the basic division (see Table 1).

Table 1 Experiment variants

Variant	Fertilizer	Dose (kg, $l.ha^{-1}$)	Composition
1	Check (for VAR 2–4)	135 kg	N 46%
2	Fertiactyl Starter – urea	2l / 135 kg	(NPK 13/5/8 + FertiActyl complex)/N 46%
3	Fertileader Gold + urea	3l / 135 kg	(B 5.7% (70 g/l) Mo 0.35% (4 g/l) Seactiv))/N 46%
4	Sulfammo 30	200kg	(N 30, 16 SO3, 3 MgO, NPRO, Mescal 975)
5	CARBONBOR	1 l	(B 185 g + C 90 g)/1 l
6	CARBONBOR Na	1 l	(B 185 g + C 90 g + Na 35g) 1 l
7	CARBONBOR K	1 l	(B 185 g + C 90 g + K_20 35 g) 1 l
8	Bortrac	1.23 l	(B 150g) / 1 l
9	Brassitrel	2.3 l	(S 115g, MgO 83g, B 80g, Mn 70g, Mo 4g)/1 kg
10	Thiotrac	10 l	(S 300g, N 200g) 1 l
11	Magnitra L	10 l	MgO 10%, N 7%/1 kg
12	$NaNO_3$	15kg	Na 27%, N 16,5%/1 kg
13	NaCl	10.2kg	Na 39,7% ,Cl 60,3%/1 kg
14	NaCl + DAM	10,2 l+6 l	Na 39,7% ,Cl 60,3%/1 kg
15	Glukorapid	4kg	N 18% gluco humates
16	Humate* + sugar + urea	80g+3kg+ 4kg	
17	CARBONBOR K + sugar	1 l+5kg	(B 185 g + C 90 g + K_20 35 g) 1 l
18	CARBONBOR Na + sugar	1 l+5kg	(B 185 g + C 90 g + Na 35g) 1 l
19	CARBONBOR + sugar	1 l+5kg	(B 185 g + C 90 g)/1 l
20	Check (for VAR 5–19)		
21	Elicitor (14)	2.5 l	Data on exact composition are subject to protection of the producer
22	Elicitor (70)	2.5 l	Data on exact composition are subject to protection of the producer
23	Elicitor (70)	2,5/10 l	Data on exact composition are subject to protection of the producer/(S 300g, N 200g) 1 l
24	Check (for VAR 21-23)		

Note:
30. May 2012 application 60 $kgN.ha^{-1}$ (VAR 1-3 urea; VAR 4 Sulfammo 30)
foliar spray (dates: VAR 2: 30 May, 7 June; VAR 3: 18 July, 29. August)

Variant 5-19 foliar spray (dates 18 July, 29 August), sugar – sucrose

Variant 21-24 application of elicitors (dates 1 August, 29 August), Elicitor (jasmonic acid based)

RESULTS AND DISCUSSION

The highest yield of roots (Fig. 1) was observed with the variant 2 (131 $t.ha^{-1}$) treated with fertilizer Fertiactyl Starter. This product has repeatedly proven suitable due to stimulation of sugar beet in the early stages of development helping to reduce the negative impacts of unfavourable soil and weather conditions. Thanks to stimulation of the root system growth and more rapid integration of vegetation, the highest yield was achieved. High yield of roots was also achieved with $NaNO_3$ (VAR 12) and 127 t.ha^{-1}. Conversely, the lowest average value (88 t.ha^{-1}) was determined after application of NaCl (VAR 13). Nevertheless, the yield for all variants ranged well above average 50-60 t.ha^{-1} as stated by Pulkrábek (2007). However, this is a small plot experiment where harvesting was done by hand (i.e., without loss) which is why the results are significantly higher. Theoretical yield potential of the sugar beet exceeds 100 t.ha^{-1} i.e. approximately 16 tonnes or more of polarisation sugar per hectare. These yields are usually achieved with small plot expriments, in practice, the yield is reduced to 40-70% (Hřivna et al., 2003).

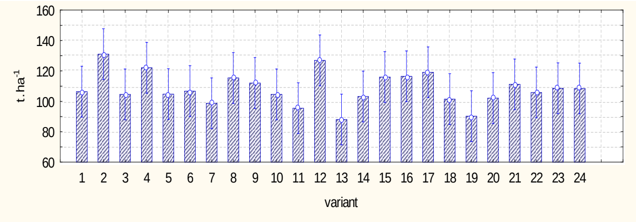

Fig. 1 Yield of roots (note: vertical columns indicate 0.95 confidence intervals)

Maximum weight of leaves (Fig. 2) at the time of harvest was detected after application of Glukorapid (VAR 15) i.e. 44 t.ha^{-1}. The lowest values were again obtained after application of NaCl solution. The growth of leaves can be supported in particular by applying appropriate dosages of nitrogen. Appropriate dosages are necessary in order to encourage the development of large enough leaf area while ensuring that the formation of leaves is not at the expense of storage of sucrose in the second stage of vegetation (Chochola, 2012). This trend was maintained as the highest yield of tops in option 15 (Glukorapid) was accompanied by a high sugar content value of 18.98%.

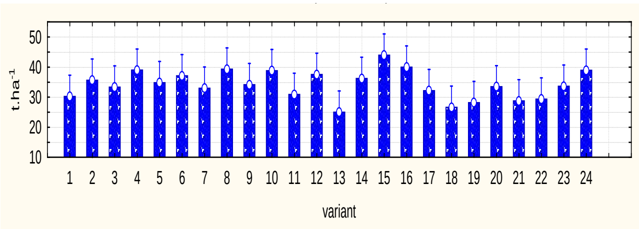

Fig. 2 Yield of tops (note: vertical columns indicate 0.95 confidence intervals)

More than 20% of sugar content (Fig. 3) was determined in two variants; variant 22 (70 + elicitor Thiotrac) achieved an average value of 20.35%. CARBONBOR (20.05%) applied to variation 5 had also positive impact on production and accumulation of sugar in the root. Boron contained in this product plays a positive role primarily in metabolism of sugars and cell division. It is important for the translocation of carbohydrates through the membrane into the root and leaf meristems, the structure and function of the cell wall (Gupta, Solanki, 2013). The lowest sugar content was achieved in variant 4 with the sole application of solid fertilizer Sulfammo 30 without foliar feeding.

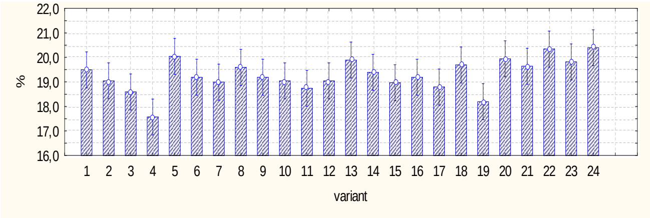

Fig. 3 Digestion (note: vertical columns indicate 0.95 confidence intervals)

The highest sugar content in molasses (Fig. 4) was in variants 1 to 4. For all these variants, compared to others, extra high doses of nitrogen were applied which contributed to an increased content of melassigenic substances and caused higher losses of sugar in molasses. The lowest losses (1.27%) were detected in variant 15 after treatment with Glukorapid. This value is favourable even at the national level, as in 2011/2012 beet campaign, the average value of sugar residues in molasses reached 1.48% (Gebler, Kožnarová, 2012).

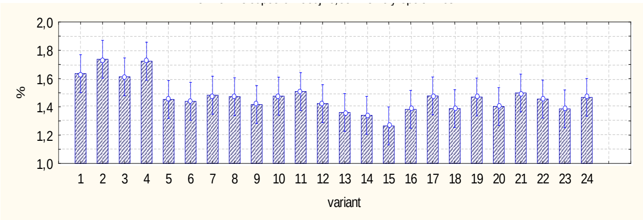

Fig. 4 Sugar content in molasses (note: vertical columns indicate 0.95 confidence intervals)

CONCLUSIONS

The highest yield of roots was achieved after the application of Fertiactyl Starter that ensured the highest growth of roots to the highest final harvest value of 131 $t.ha^{-1}$. At the time of harvest, the highest weight of tops was determined after application of Glukorapid. Overall, the lowest weight of the plants was detected after spraying with sodium chloride solution. The highest sugar content was observed after application of fertilizers CARBONBOR and combination of Elicitor 70 + Thiotrac. The biggest losses of sugar in molasses were established with variants to which high doses of nitrogen had been applied. On the contrary, technologically best sugar beets were harvested from variant treated with Glukorapid reducing the losses of sugar in molasses to only 1.27%.

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