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# THE ECONOMIC EFFECTS OF FOLIAR FERTILIZATION OF SUGAR BEET WITH MARINE CALCITE

Key words: foliar fertilization, marine calcite, profitability of production, silicon, sugar beet

ABSTRACT. In 2010-2012, in Sahryń (Lubelskie Voivodeship), a field experiment was carried out, the aim of which was to assess the cost-effectiveness of foliar nutrition of sugar beet with marine calcite Herbagreen Basic containing silicon. The fertilizer was applied in two variants: 1) 1 kg/ha at the 4-6 leaf stage of sugar beet (BBCH 14-16) + 2 kg/ha 21 days later; 2) 2 kg/ha at the 4-6 leaf stage of sugar beet (BBCH 14-16) + 2 kg/ha 21 days later; the effects were compared with the control (without foliar nutrition with marine calcite). Additionally, in the years 2011-2012, an identical experiment was carried out with another sugar beet cultivar. For each combination, the gross production value, foliar nutrition costs, the net production value and profitability index were calculated. The total cost of application of foliar calcite was 190 and 240 PLN/ha. The gross production value of sugar beet in experiment 1, on average over three years of research, increased in combination 1 by 24.8% and in combination 2 by 25.6% compared to the control; in experiment 2, on average for 2 years of research, in combination 1 by 15.7%, and in combination 2 by 15.0%. The increase in the net production value in experiment 1 amounted to 22.8 and 23.2% respectively, and in experiment 2 - 13.9 and 12.8%. The indicator of the profitability of foliar nutrition with marine calcite in experiment 1, on average, for the period 2010-2012, amounted to 12.6 in combination 1 and 10.3 in combination 2. In experiment 2, the index of profitability of foliar nutrition, on average, for the period 2011-2012, reached the value of 8.96 for object 1 and 6.77 for object 2.

## INTRODUCTION

In agriculture, there is increasing interest in the use of silicon for foliar nutrition of plants [Artyszak 2018]. One of the products containing silicon is properly prepared marine calcite. The beneficial effect of marine calcite on the yield of sugar beet is evidenced by the results of many experiments carried out by Arkadiusz Artyszak [Artyszak 2017] and A. Artyszak et al. [2014, 2015, 2016]. The same applies to oilseed rape [Artyszak, Kucińska 2016] and potato [Trawczyński 2013, 2018]. The beneficial effect of the application of foliar calcite in the cultivation of lettuce was found in Serbia [Ugrinović et al. 2011], grapes in Turkey [Kara, Sabir 2010] and hops in Germany [Weihrauch et al. 2011]. In Albania, using Herbagreen in maize and wheat cultivation, with reduced NPK fertilization by 30%, the same protein and fat content was obtained in grain as at the full NPK dose [Prifti, Maçi 2017]. Jalamang Camara et al. reported on the beneficial effects of Herbagreen fertilizer used to reduce pesticide incidence and disease in the cultivation of tomato in Ghana [2017].

The aim of the study is to assess the cost-effectiveness of foliar nutrition of sugar beet with marine calcite containing, among others, silicon.

## MATERIAL AND METHODS

Although the results used to prepare the publication come from experience of a few years ago, their relevance have not faded. There is only one publication about the cost-effectiveness of using silicon in the cultivation of sugar beet [Artyszak et al. 2019].

Data for analyses come from two field experiments conducted in 2010-2012 in Sahryń, in the Lublin Voivodeship. Detailed results of sugar beet yield and the technological quality of the roots of the experiments are presented in the publications of A. Artyszak et al. [2014, 2016].

Sugar beet was grown on soil belonging to the soil group Chernozems (CH) [FAO 2006]. Sugar beet was grown in crop rotation after winter wheat. The amount of rainfall during the growing season (April – October) was: in 2010, 600 mm, in 2011, 531 mm and in 2012, 532 mm (the average for years 1991-2013 is 439 mm). The average daily temperature was 14.6, 14.7 and 15.2°C (average for many years 14.2°C). The most favourable weather conditions for the growth and yielding of sugar beet was observed in the year 2011.

In the experiments, finely ground Herbagreen Basic marine calcite (Table 1) was used. The effects were compared with the control (without foliar nutrition). Herbagreen Basic mainly contains Ca – 26.2% and Si – 7.99%, and additionally a small amount of the following: Fe, Mg, K, Na, Ti, P, S, Mn, B, Co, Cu and Zn.

The number of replications in each experiment was 4. Each plot included 6 rows and an area of 43.2 $m^2$ (length 16 m and width 2.7 m). The product doses are based on the manufacturer's recommendations. The application was made with the Apollo (Krukowiak) tractor sprayer on dates resulting from experiment design. The dose of water in each treatment was 250 $dm^3$/ha. During harvesting, on three central rows, on a plot measuring 21.6 $m^2$, root yield was determined. Representative root samples were also taken to evaluate the technological quality (content of sugar and molasses components), which was determined on the Venema line in Kutnowska Hodowla Buraka Cukrowego Sp. z o.o. in Straszków.

Real root yields were converted into yield at 16% sugar content in order to calculate gross production value. The beet purchase prices are quoted according to the journal *The*

Table 1. Description of the treatments applied in the experiment

| Variant | Characteristics |
|---|---|
| 0 | Control – without foliar application of marine calcite |
| 1 | Herbagreen Basic (1 kg/ha) in the 4-6 leaf-stage of sugar beet + Herbagreen Basic (2 kg/ha) 21 days later |
| 2 | Herbagreen Basic (2 kg/ha) in the 4-6 leaf-stage of sugar beet + Herbagreen Basic (2 kg/ha) 21 days later |

Source: own elaboration

*sugar market* [IERiGŻ-PIB 2018]. They amounted to 113.1 PLN/t in 2010, PLN 144.0 in 2011 and PLN 137.2 in 2012. The cost of a single foliar application was 20 PLN/ha. Product prices are given after data was provided by the manufacturer – 50 PLN/kg. The net production value was calculated (i.e. the value of gross production minus the total costs of performing foliar treatments). The profitability index of foliar nutrition as a quotient of the increase in the value of gross production and the increase in costs was also calculated. The results obtained were statistically analysed using the analysis of variance and multiple comparisons of the Tukey procedure. To compare means, the significance level $\alpha = 0.05$ was assumed. The calculations were performed in the Statistica 13 program. Standard deviation (SD) and coefficient of variation (CV) were calculated.

## RESULTS

The effect of foliar nutrition with marine calcite on root yield (16% sugar content) was very different in the years of research (Table 2). In experiment 1, on average for the years 2010-2012, a significant increase in root yield was observed, respectively, by 23.8% in combination 1 and by 24.5% in relation to the control. In this experiment, significant differences were only found in 2011, when they amounted to over 50%. While in 2010, it was 16.9% and 13.0%. In 2012, in combination 1, yields were the same as in the control variant and, in combination 2, higher by 7.8% compared to the control. In experiment 2, on average, in two years, the increase in root yield in variant 1 was 15.9%, and, in 2, 15.1% in comparison to the control, but this difference was not significant. In 2011, it was, respectively: 11.4 and 13.8%, and a year later – 22.1 and 16.8%. The variability of root yield was the lowest in 2010 (CV = 15.0%), and the highest in 2011 in experiment 1 (CV = 27.2%).

In studies carried out with other marine calcite – Herbagreen Z20, an average of 2 years of research, the increase in root yield was 8.9% for a single application, 8.3% for a double and 9.7% for a triple application [Artyszak et al. 2019].

The gross production value of sugar beet, in experiment 1, on average for 3 years of research, increased in combination 1 by 24.8% and in combination 2 by 25.6% in relation to the control (Table 3). The largest increase was observed in 2011 – 53.5 and 50.7%. While in 2012, a slight reduction in gross production value was observed in combination 1, in combination 2 there was an increase of 7.8%. In experiment 2, the increase in gross production value, due to the application of foliar spray by marine calcite, on average for 2 years of research, in combination 1 was by 15.7%, and in 2 by 15.0% in comparison with the control variant. These increases in 2012 were higher (22.2 and 16.8%, respectively) than in 2011 (11.4 and 13.8%).

The costs of purchasing the product and its application in the years of research were the same and amounted to, in combination 1 – 190 PLN/ha, and in combination 2 – 240 PLN/ha.

The value of net production was similar to the value of gross production. In experiment 1, on average, for 3 years of research, it increased in combination 1 by 22.8% and in 2 by 23.2% in relation to the control object. The largest increases were observed in 2011, 51.8 and 48.6%, respectively. In contrast, in 2012, the net production value decreased

Table 2. Yield of sugar beet roots (16% sugar content) depending on foliar fertilization with marine calcite (Sahryń, 2010-2012)

| Variant* | Yield of sugar beet roots [t/ha] | | | |
|---|---|---|---|---|
| Experiment 1 | | | | |
| | 2010 | 2011 | 2012 | 2010-2012 |
| 0 | 68.6 a | 77.1 a | 73.5 a | 73.1 a |
| 1 | 80.2 a | 118.4 b | 73.0 a | 90.5 b |
| 2 | 77.5 a | 116.3 b | 79.2 a | 91.0 b |
| SD | 11.3 | 28.3 | 15.1 | 23.5 |
| CV [%] | 15.0 | 27.2 | 20.1 | 27.6 |
| Experiment 2 | | | | |
| | 2010 | 2011 | 2012 | 2011-2012 |
| 0 | – | 91.2 a | 62.5 a | 76.8 a |
| 1 | – | 101.6 a | 76.3 a | 89.0 a |
| 2 | – | 103.8 a | 73.0 a | 88.4 a |
| SD | – | 20.9 | 14.1 | 22.7 |
| CV [%] | – | 21.8 | 20.0 | 26.8 |

SD – standard deviation, CV – coefficient of variation
* descriptions as in table 1
** the same letters in columns indicate no significant differences at $\alpha = 0.05$ probability level
Source: own elaboration

by 2.6% on object 1 and increased by 5.4% on object 2. In experiment 2, the increase in net production value, on average for 2 years of research, amounted to 13.9 and 12.8%. In 2012, it was higher (20.0 and 14.0%) than in 2011 (10.0 and 12.0%).

The indicator of the cost-effectiveness of foliar nutrition with marine calcite in experiment 1, on average for the period 2010-2012, was 12.6 in combination 1 and 10.3 in combination 2. The highest value was obtained in 2011 (31.3 and 23.5, respectively), and the smallest in 2012 -0.37 and 3.26. In experiment 2, the cost-effectiveness index for foliar nutrition, on average for the period 2011-2012, reached 8.96 on site 1 and 6.77 on site 2. In 2011, it was 7.91 and 7.56 and in 2012, 10.0 and 5.99.

The coefficient of variation (CV) in gross production value ranged from 15.0% in 2010 to 27.2% in 2011, in experiment 1. Similarly, in the case of net production value; 14.7 and 27.0%. The CV value for the profitability index ranged from 111% in 2011 to 1,003% in 2012, in experiment 1.

In the studies of A. Artyszak et al. [2019] the single application of Herbagreen Z20 fertilizer, on average in the years 2015-2016, caused an increase in the value of gross production by 8.7%, double application by 8.4% and triple application by 9.8%. The costs of purchasing the product and its use were 78, 156 and 234 PLN/ha. The net production value increased by 7.7, 6.4 and 6.8%. The profitability index was 8.81 when one application was performed, 4.24 – with two applications and 3.30 – for three.

Table 3. The value of production of sugar beet depending on foliar fertilization with marine calcite (Sahryń, 2010-2012)

| Variant* | Gross production value [PLN/ha] | Costs [PLN/ha] | | | Net production value [PLN/ha] | Profitability index |
|---|---|---|---|---|---|---|
| | | application | costs of products | total | | |
| Experiment 1 | | | | | | |
| 2010 | | | | | | |
| 0* | 7,760 a** | 0 | 0 | 0 | 7,760 a | 0,0 a |
| 1 | 9,064 a | 40 | 150 | 190 | 8,874 a | 6.87 a |
| 2 | 8,764 a | 40 | 200 | 240 | 8,524 a | 4.19a |
| SD | 1,276 | – | – | – | 1,235 | 6.3 |
| CV [%] | 15.0 | – | – | – | 14.7 | 172 |
| 2011 | | | | | | |
| 0 | 11,117 a | 0 | 0 | 0 | 11,117 a | 0.0 a |
| 1 | 17,066 b | 40 | 150 | 190 | 16,876 b | 31.3 a |
| 2 | 16,755 b | 40 | 200 | 240 | 16,515 b | 23.5 a |
| SD | 4,072 | – | – | – | 4,000 | 20.2 |
| CV [%] | 27.2 | – | – | – | 27.0 | 111 |
| 2012 | | | | | | |
| 0 | 10,083 a | 0 | 0 | 0 | 10,083 a | 0.0 a |
| 1 | 10,013 a | 40 | 150 | 190 | 9,823 a | -0.37 a |
| 2 | 10,866 a | 40 | 200 | 240 | 10,626 a | 3.26 a |
| SD | 2,073 | – | – | – | 2,063 | 9.7 |
| CV [%] | 20.1 | – | – | – | 20.3 | 1,003 |
| 2010-2012 | | | | | | |
| 0 | 9,653 a | 0 | 0 | 0 | 9,653 a | 0.0 a |
| 1 | 12,048 b | 40 | 150 | 190 | 11,858 b | 12.6 b |
| 2 | 12,128 b | 40 | 200 | 240 | 11,888 b | 10.3 b |
| SD | 3,831 | – | – | – | 3,801 | 15.2 |
| CV [%] | 34.0 | – | – | – | 34.1 | 198 |
| Experiment 2 | | | | | | |
| 2011 | | | | | | |
| 0 | 13,143 a | 0 | 0 | 0 | 13,143 a | 0.0 a |
| 1 | 14,645 a | 40 | 150 | 190 | 14,455 a | 7.91 a |
| 2 | 14,957 a | 40 | 200 | 240 | 14,717 a | 7.56 a |
| SD | 3,017 | – | – | – | 2,990 | 15.8 |
| CV [%] | 21.2 | – | – | – | 21.2 | 306 |

Table 3. Cont.

| Variant* | Gross production value [PLN/ha] | Costs [PLN/ha] | | | Net production value [PLN/ha] | Profitability index |
|---|---|---|---|---|---|---|
| | | application | costs of products | total | | |
| 2012 | | | | | | |
| 0 | 8,572 a | 0 | 0 | 0 | 8,572 a | 0.0 a |
| 1 | 10,473 a | 40 | 150 | 190 | 10,283 a | 10.01 a |
| 2 | 10,009 a | 40 | 200 | 240 | 9,769 a | 5.99 a |
| SD | 1,936 | – | – | – | 1,895 | 8.6 |
| CV [%] | 20.0 | – | – | – | 19.9 | 162 |
| 2011-2012 | | | | | | |
| 0 | 10,857 a | 0 | 0 | 0 | 10,857 a | 0.0 a |
| 1 | 12,559 a | 40 | 150 | 190 | 12,369 a | 8.96 a |
| 2 | 12,483 a | 40 | 200 | 240 | 12,243 a | 6.77 a |
| SD | 3,403 | – | – | – | 3,380 | 12.5 |
| CV [%] | 28.4 | – | – | – | 28.6 | 237 |

SD – standard deviation; CV – coefficient of variation; * descriptions as in Table 1; **the same letters in columns indicate no significant differences at $\alpha = 0.05$ probability level

Source: own elaboration

## CONCLUSIONS

1. Foliar nutrition with marine calcite has a beneficial effect on the profitability of sugar beet production, but the impact is extremely variable over years.
2. The increase in the net production value of sugar beet is independent of the combination of foliar nutrition with marine calcite.
3. A bigger cost-effectiveness index was observed for the application of Herbagreen Basic calcite in the first treatment at a dose of 1 kg/ha than 2 kg/ha.

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## EFEKTY EKONOMICZNE DOKARMIANIA DOLISTNEGO BURAKA CUKROWEGO KALCYTEM MORSKIM

Słowa kluczowe: kalcyt morski, krzem, dokarmianie dolistne, burak cukrowy, opłacalność produkcji

ABSTRAKT

W latach 2010-2012 w Sahryniu (woj. lubelskie) prowadzono doświadczenie, którego celem była ocena opłacalności dokarmiania dolistnego buraka cukrowego kalcytem morskim Herbagreen Basic zawierającym krzem. Nawóz stosowano w dwóch wariantach: (1) 1 kg/ha w stadium 4-6 liści buraka cukrowego (BBCH 14-16) + 2 kg/ha 21 dni później; (2) 2 kg/ha w stadium 4-6 liści buraka cukrowego (BBCH 14-16) + 2 kg/ha 21 dni później, a efekty porównywano z kontrolą (bez dokarmiania dolistnego kalcytem morskim). Dodatkowo, w latach 2011-2012 wykonano identyczne doświadczenie na innej odmianie buraka cukrowego. Dla każdej kombinacji wyliczono wartość produkcji brutto, koszty dokarmiania dolistnego, wartość produkcji netto oraz wskaźnik opłacalności. Łączne koszty aplikacji dolistnej kalcytu morskiego wynosiły 190 i 240 zł/ha. Wartość produkcji brutto buraka cukrowego w doświadczeniu 1. średnio za 3 lata badań zwiększyła się w kombinacji (1) o 24,8%, a w kombinacji (2) o 25,6% w stosunku do kontroli, a w doświadczeniu 2. średnio za 2 lata badań w kombinacji (1) o 15,7%, a w kombinacji (2) o 15,0%. Wzrost wartości produkcji netto w doświadczeniu 1. wyniósł odpowiednio 22,8 i 23,2%, a w doświadczeniu 2. – 13,9 i 12,8%. Wskaźnik opłacalności dokarmiania dolistnego kalcytem morskim w doświadczeniu 1. średnio za okres 2010-2012 wyniósł 12,6 w kombinacji 1. i 10,3 w kombinacji 2. W doświadczeniu 2. wskaźnik opłacalności dokarmiania dolistnego średnio za okres 2011-2012 osiągnął wartość 8,96 na obiekcie 1. i 6,77 na obiekcie 2.

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