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PROFITABILITY OF SUGAR BEET FOLIAR NUTRITION WITH SILICON

Key words: silicon, foliar nutrition, sugar beet, profitability of production

ABSTRACT. In the years 2015-2016 in Sahryń (50°41′ N, 23°47’ E) a field experiment, with the aim of assessing profitability of foliar nutrition of sugar beet with silicon, was carried out. The following products containing silicon were used in the experiment: Actisil, Herbagreen Z20 and Optysil. Each of them was applied once, twice and thrice. For each combination, the gross production value, the costs of foliar nutrition, the net production value and the profitability index were calculated. The total costs of silicon foliar application varied depending on the number of treatments and the applied product from 50 to 402 PLN/ha. The gross production value of sugar beet due to foliar nutrition with silicon increased by 1.3-22.9% for the research period, and the net production value by 5.5-19.0%. A large variation in the achieved financial results was observed in 2015, in which there were particularly unfavorable conditions for the growth and yield of sugar beet. In the more favorable year for growing sugar beet (2016), the difference was smaller. The largest increase in the gross and net production value of sugar beet was ensured by the double and triple application of Actisil fertilizer and the triple application of the Optysil growth stimulator. However, the largest profitability indicator (11.26) was characterized by a single Optysil growth stimulator application.

INTRODUCTION

Arkadiusz Artyszak [2018] believes that foliar nutrition with silicon should be introduced into production as a standard treatment in the cultivation of many agricultural plant species. The foliar application with stabilized silicic acid can be treated as an “insurance policy” in plant-friendly environmental conditions resulting, for example, from climate change [Laane 2018].

The results of many experiments show the beneficial effect of silicon on plant growth, the size and quality of maize yield [Ciecierski et al. 2017], oilseed rape [Ciecierski, Kardasz 2014, Artyszak, Kucińska 2016, Gugała et al. 2017], peas and white lupine [Sulewska et al. 2018], soy [Kalandyk et al. 2014], potato [Trawczyński 2013, Wróbel 2012] and even permanent grassland [Radkowski et al. 2017]. Since 2010 research has been carried out on foliar fertilization of sugar beet with silicon, which indicates a positive effect of the use of this element on sugar yield [Artyszak 2017, Artyszak, Kucińska 2016, Artyszak et al. 2014, 2015, 2016, Hřivna et al. 2017, Urban, Pulkrábek 2018].

The aim of the work is to evaluate the profitability of foliar nutrition with silicon of sugar beet used in several products and combinations.

MATERIAL AND METHODS

The experiment was carried out in 2015-2016 in Sahryń (50°41′ N, 23°47’ E) in Werbkowice Commune, Hrubieszów Poviat, Lublin Province.

Sugar beet was grown on soil belonging to the Chernozems (CH) soil [FAO 2006]. According to the Polish classification system, it belongs to the heavy agronomy category (IV), class IIIa, classified as a good wheat complex. Sugar beet was grown in the fourth cycle of the following rotation: sugar beet – winter wheat – winter rape.

Years of research were characterized by unfavorable weather conditions for the growth and yield of sugar beet. According to the limit values adopted by Marian Molga [1986], extreme drought prevailed in August 2015 and September 2016, and drought in June 2015. The occurrence of semi drought was recorded in June and August 2016. Two foliar fertilizers were used in the experiment: Actisil (stabilized orthosilicic acid, alkaline), Herbagreen Z20 (finely ground marine calcite) and growth stimulator Optysil (neutral, stabilized orthosilic and polysilicic acid). Each of the tested products was used in three variants and compared to the control (without foliar nutrition with silicon) (table 1). The number of replications was 4, and the total number of plots 40. Each plot included 6 rows and an area of 43.2 m^2 (length 16 m and width 2.7 m). The product doses were based on the manufacturers’ recommendations as well as on the results of previous own studies, listed in table 1. The application was made with the Appollo (Krukowiak) tractor sprayer in terms of the scheme resulting from experience. In the year of 2015 spraying was carried out on the following days: May 23rd , May 30th and June 6th , and in 2016 on May 27th , June 3rd and June 10th . The dose of water in each spray was 250 dm^3/ha. Root yield was determined during harvesting on 3 central rows on a plot area of 21.6 m^2. Representative root samples were also taken to evaluate its 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. Detailed results of sugar beet yield and the technological quality of roots are presented in the publication by A. Artyszak [2017].

Actual root yields were converted into yield by 16% sugar content in order to calculate gross production value. The minimum purchase price of 1 t of roots with a 16% sugar content was calculated as a product of EUR 26.29 with the average EUR exchange rate in September before the beginning of a given marketing year in accordance with the announcement of the European Central Bank: in 2015 PLN 1 EUR = PLN 4.2176 and 2016, 1 EUR = PLN 4.3207. The minimum purchase price per 1 tonne was PLN 110.88 in 2015 and PLN 113.59 a year later. The cost of making a single foliar application with products containing silicon is 25 PLN/ha. The product prices are given for the following producers: Actisil – 218 PLN/dm^3, Herbagreen Z20 – 53 PLN/kg, and Optysil – 50 PLN/dm^3. Then the value of net production was calculated (gross value of production reduced by 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

Table 1. Description of facilities and treatments conducted

Variant	Characteristics
0	Control – without foliar application of the tested preparations
1	Actisil (0.5 dm^3/ha) – 6-leaf stage of sugar beet
2	Actisil (0.5 dm^3/ha) – 6-leaf stage of sugar beet + Actisil (0.5 dm^3/ha) 7 days later
3	Actisil (0.5 dm^3/ha) – 6-leaf stage of sugar beet + Actisil (0.5 dm^3/ha) 7 days later + Actisil (0.5 dm^3/ha) 14 days later after the first application
4	Herbagreen Z20 (1 kg/ha) – 6-leaf stage of sugar beet
5	Herbagreen Z20 (1 kg/ha) – 6-leaf stage of sugar beet + Herbagreen Z20 (1 kg/ha) 7 days later
6	Herbagreen Z20 (1 kg/ha) – 6-leaf stage of sugar beet + Herbagreen Z20 (1 kg/ha) 7 days later + Herbagreen Z20 (1 kg/ha) 14 days later after the first application
7	Optysil (0.5 dm^3/ha) – 6-leaf stage of sugar beet
8	Optysil (0.5 dm^3/ha) – 6-leaf stage of sugar beet + Optysil (0.5 dm^3/ha) 7 days later
9	Optysil (0.5 dm^3/ha) – 6-leaf-stage of sugar beet + Optysil (0.5 dm^3/ha) 7 days later + Optysil (0.5 dm^3/ha) 14 days later after the first application

Source: own study

was also calculated The calculations were conducted in Excel. The results were analyzed statistically using analysis of variance and Tukey's method of multiple comparison. For comparison, the means significance level was set at $\alpha = 0.05$. The calculations were performed with SAS 9.1 software using the GLM procedure.

RESULTS

The foliar nutrition variants applied in the experiment caused a significant increase in root yield (sugar content 16%), which for the years 2015-2016 varied from 6.9 to 24.0% depending on the variant (table 2). The largest increase in root yield was noted in option 3 (24.0%), 2 (23.7%) and 9 (17.0%). Particularly large effects were observed in 2015, characterized by a very large water shortage and high temperature during the growing season. The increase in root yield reached, in variant 2, up to 37.0%, in variant 3 – 35.6%, and in variant 9 – 26.0%. A year later, the variability of root yield was significantly smaller, and its increase ranged from 5.8% (option 8) to 13.7% (option 3).

The gross production value of sugar beet due to foliar nutrition with silicon increased by 1.3-22.9% during the research period (table 3). The costs of purchasing products and their application in the years of research were the same and amounted depending on the num-

Table 2. Yield of sugar beet depending on foliar nutrition variants (Sahryń, 2015-2016)

Variant*	Root yield of 16% of sugar content [t/ha]		
	2015	2016	2015-2016
0	59.8 a**	80.7 a	69.9 a
1	64.1 ab	86.6 ab	75.0 ab
2	81.9 c	90.3 ab	86.5 c
3	81.1 c	91.8 b	86.7 c
4	66.8 ab	86.0 ab	76.1 ab
5	64.3 ab	88.0 ab	75.7 ab
6	64.8 ab	89.5 ab	76.7 ab
7	63.0 ab	87.6 ab	74.8 ab
8	67.1 ab	85.4 ab	76.1 ab
9	75.4 bc	88.2 ab	81.8 bc

* descriptions as in table 1

** the same letters in columns indicate no significant differences at a $\alpha = 0.05$ probability level

Source: own study

ber of applications and the applied product from 50 to 402 PLN/ha. The increase in the value of net production for the years 2015-2016 ranged from PLN 434 to PLN 1500/ha (5.5-19.0%). A large variation in the obtained result was observed in 2015, in which there were particularly unfavorable conditions for the growth and yield of sugar beet. In the more favorable year 2016, this difference was smaller. On average, the best results for the entire study period were found in the case of the Actisil foliar fertilizer applied two- and three-fold (variants 2 and 3) and three applications of the Optysil growth stimulator (variant 9).

The index of foliar nutrition profitability with silicon, on average, for the years 2015-2016, was in the range of 3.30-11.26. The highest value was achieved with a single application of Optysil (variant 7). The situation was similar in 2016, when the profitability index was 15.52 for this variant. However, in 2015, the highest value was obtained with the 3-time application of the Optysil growth stimulator (variant 9). Obtained results of own research confirm the opinion of Henk-Maartin Laane [2017] about the profitability of foliar nutrition with silicon.

CONCLUSIONS

1. Silicon foliar nutrition, irrespective of the number of applications and products used, had a beneficial effect on the profitability of sugar beet production. Significant beneficial effects were obtained in the year in which a shortage of water for the plant occured.
2. The largest increase in the net production value of sugar beet was ensured by the two foliar and triple foliar application of the Actisil fertilizer and the triple application of the Optysil growth stimulator.
3. The highest profitability index was observed for the single Optysil growth stimulator application in the 6-leaf stage of sugar beet (BBCH 16).

Table 3. The value of sugar beet production depending on foliar nutrition variant (Sahryń, 2015-2016)

Variant*	Gross production value [PLN/ha]	Costs [PLN/ha]			Net production value [PLN/ha]	Difference in relation to control [PLN/ha]	Profitability index
		application	costs of products	total			
2015							
0	6,633 a**	–	–	–	6,633 a	–	–
1	7,103 ab	25	109	134	6,969 ab	+336	3.51
2	9,085 c	50	218	268	8,817 c	+2184	9.15
3	8,993 c	75	327	402	8,591 c	+1958	5.87
4	7,409 ab	25	53	78	7,331 abc	+698	9.95
5	7,132 ab	50	106	156	6,976 ab	+343	3.20
6	7,186 ab	75	159	234	6,952 ab	+319	2.36
7	6,983 ab	25	25	50	6,933 ab	+301	7.01
8	7,445 ab	50	50	100	7,345 abc	+713	8.13
9	8,357 bc	75	75	150	8,207 bc	+1575	11.50
2016							
0	9,172 a	–	–	–	9,172 a	–	–
1	9,837 ab	25	109	134	9,703 a	+531	4.96
2	10,255 ab	50	218	268	9,987 a	+815	4.04
3	10,430 b	75	327	402	10,028 a	+856	3.13
4	9,769 ab	25	53	78	9,691 a	+519	7.66
5	9,995 ab	50	106	156	9,839 a	+667	5.28
6	10,163 ab	75	159	234	9,929 a	+757	4.24
7	9,948 ab	25	25	50	9,898 a	+726	15.52
8	9,703 ab	50	50	100	9,603 a	+431	5.31
9	10,016 ab	75	75	150	9,866 a	+694	5.63
2015-2016							
0	7,902 a	–	–	–	7,902 a	–	–
1	8,470 ab	25	109	134	8,336 ab	+434	4.24
2	9,670 c	50	218	268	9,402 d	+1500	6.60
3	9,711 c	75	327	402	9,309 cd	+1407	4.50
4	8,589 ab	25	53	78	8,511 abcd	+609	8.81
5	8,564 ab	50	106	156	8,408 abc	+505	4.24
6	8,675 ab	75	159	234	8,441 abc	+538	3.30
7	8,465 ab	25	25	50	8,415 abc	+513	11.26
8	8,574 ab	50	50	100	8,474 abcd	+572	6.72
9	9,186 bc	75	75	150	9,036 bcd	+1134	8.56

* descriptions as in table 1

** the same letters in columns indicate no significant differences at a $\alpha = 0.05$ probability level

Source: own study

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OPŁACALNOŚĆ DOKARMIANIA DOLISTNEGO BURAKA CUKROWEGO KRZEMEM

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

ABSTRAKT

W latach 2015-2016 w Sahryniu (50°41′ N, 23°47’ E) prowadzono doświadczenie, którego celem była ocena opłacalności dokarmiania dolistnego buraka cukrowego krzemem. W doświadczeniu stosowano następujące produkty zawierające krzem: Actisil, Herbagreen Z20 oraz Optysil. Każdy z nich był aplikowany jedno-, dwu- i trzykrotnie. Dla każdej kombinacji wyliczono wartość produkcji brutto, koszty dokarmiania dolistnego, wartość produkcji netto oraz wskaźnik opłacalności. Łączne koszty aplikacji dolistnej krzemu wynosiły od 50 do 402 zł/ha, w zależności od liczby zabiegów oraz zastosowanego produktu. Wartość produkcji brutto buraka cukrowego na skutek dokarmiania dolistnego krzemem zwiększyła się za okres badań o 1,3-22,9%, a wartość produkcji netto o 5,5-19,0%. Duże zróżnicowanie w uzyskanych wynikach finansowych zaobserwowano w 2015 roku, w którym panowały szczególnie niekorzystne warunki dla wzrostu i plonowania buraka cukrowego. W bardziej korzystnym dla uprawy buraka cukrowego 2016 roku zróżnicowanie to było mniejsze. Największy wzrost wartości produkcji brutto i netto buraka cukrowego zapewniało dwu- i trzykrotne zastosowanie dolistne nawozu Actisil oraz trzykrotna aplikacja stymulatora wzrostu Optysil. Natomiast największy wskaźnik opłacalności (11,26) odnotowano przy jednokrotnej aplikacji stymulatora wzrostu Optysil.

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