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# SUGAR BEET MORPHOLOGICAL TRAITS AFTER FOLIAR APPLICATION WITH MARINE CALCITE

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**Abstract.** The effect of marine calcite foliar application on the sugar beet root morphological features relative to the control (treatment 0) was investigated. Study was conducted in 2010–2012 in the southeastern region of Poland, in Sahryń (50°41′ N and 23°46′ E). The variety of sugar beet was Britannia. Two treatments of foliar application with marine calcite were used: 1) treatment (at the growth stage of 4–6 sugar leaf – 1 kg Herbagreen·ha$^{-1}$, and three weeks later – 2 kg Herbagreen·ha$^{-1}$); and 2) treatment (at the growth stage of 4–6 sugar leaf – 2 kg Herbagreen·ha$^{-1}$, three weeks later – 2 kg Herbagreen·ha$^{-1}$). Foliar application with marine calcite had the significant and profitable effect for such features like: content of dry matter in the leaf blades, dry matter and area of the leaf blades and the number of leaves per sugar beet plant. In the experiment the tendency to the higher dry matter accumulation in the petioles and the storage roots as the effect of foliar application were also observed. Storage roots yield, biological and technological sugar yields were positively correlated with dry matter yield of storage roots, with the total yield of dry matter (roots and leaves) and with the harvest index in all fertilization treatments. Correlations of storage root yield, biological and technological sugar yields with dry matter of petioles or with the number of leaves were significant in the second treatment only. Sugar content in the storage roots was positively correlated with the number of leaves per plant.

**Key words:** dry matter, foliar application, harvest index, leaf morphology, silicon

## INTRODUCTION

The foliar application of ground marine rocks mainly containing calcite carbonate ($CaCO_3$) and silicon ($SiO_2$) is a new issue in fertilization practice. Herbagreen Basic is one such kind of fertilizers. Silicone (Si) is one of the major component of this fertilizer. This nutrient has the beneficial effect for many plant species [Currie and Perry 2007, Guntzer et al. 2012]. Calcium is an essential plant nutrient also [White and Broadley 2003]. It is an essential plant nutrient however deficiency symptoms of calcium are rarely seen in the field because production is done on neutral soils. Even in soils with pH as low as 5.5, there is often sufficient calcium to support crop growth [Christenson and Draycott 2006]. Herbagreen's positive effect was observed by some authors in such crops like: lettuce [Ugrinović et al. 2011], chop [Weihrauch et al. 2011], potatoes [Trawczyński 2013], sugar beet [Artyszak et al. 2014, 2015 and 2016b]. Millford [2006] informed that according to the Scott and Jaggard, [1993] research, the seasonal patterns of production and distribution of dry matter in sugar beet are relatively consistent, with much of

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the dry matter being in the shoot during early growth and in the storage root at harvest – when the majority of the dry matter is present as sugar. However, according to Bell et al. [1996] the exact proportions of the total dry matter that are allocated to the storage root and to stored sugar are influenced considerably by harvest date, genotype, nitrogen fertilizer, plant density, soil type and seasonal weather – especially occurrence of drought at critical stages of crop growth**.** Despite the proven effects of micronutrients on morphological features of sugar beet plants [Bergen 1967, Hellal et al. 2009], however there are no studies on the effect of marine calcite on the morphological features of sugar beet.

The main goal of described research was the estimation of the foliar fertilization with marine calcite effect on the morphological features of sugar beet plants, Britannia variety.

## MATERIALS AND METHODS

In 2010–2012, the experiment was carried out in the southeastern part of Poland in Sahryń village (50°41′ N and 23°46′ E). Soil and weather conditions during the experiment were described in the paper of Artyszak et al. [2016b]. The soil was classified as Chernozem [FAO 2006]. The average $pH_{KCL}$ was 6.97; macro and micronutrient contents in the soil ($mg \cdot kg^{-1}$): P – 98.2; K – 94.1; Mg – 60.7; B – 1.12; Cu – 4.3; Fe – 727; Mn – 168 and Zn – 5.7. The amounts of rainfall during the growing seasons (April–October) were: 600 mm in 2010, 531 mm in 2011 and 532 in 2012, while the average daily air temperature was: 14.6°C in 2010, 14.7°C in 2011 and 15.2°C in 2012.

The chemical composition of fertilizer Herbagreen Basic is as follows (% m/m): Ca – 26.2, Si – 7.99, Fe – 2.38, Mg – 1.45, K – 0.42, Na – 0.37, Ti – 0.3, P – 0.22, S – 0.16, Mn – 0.08 and trace amount of B, Co, Cu and Zn. This fertilizer was applied as a solution respectively to the term: 1) first term at the 4–6 leaf growth stage (BBCH 14–16) – with 0.4 % concentration in the first treatment and with 0.8% in the second one; 2) second term (3 weeks later) with 0.8 % concentration in both treatments (Table 1). The amount of water for spraying was 0.25 $m^3$ per

Table 1. Scheme of experiment

| Terms of use/dose | Treatments of foliar fertilization (A) | | |
|---|---|---|---|
| | 0 | 1 | 2 |
| 4–6 leaf stage (BBCH 14–16) | – | 1 kg Herbagreen | 2 kg Herbagreen |
| 3 weeks later | – | 2 kg Herbagreen | 2 kg Herbagreen |
| The total dose, $kg \cdot ha^{-1}$ | – | 3 kg Herbagreen | 4 kg Herbagreen |

ha, each time. Number of replication was 4. Single plot area was 43.2 $m^2$. From every second row of each plot the 4 plants were randomly collected directly before harvesting. There were 16 plants per each year from each fertilization treatment. For each plant fresh matter of blade, petioles and root as well as number of leaves were determined.

For determination of dry matter content 100 g samples of leaf blades, petioles and roots were taken from each plant, and dried in a dryer at 105°C. The leaf area was determined by the disks' methods. From each plant 25 disc were randomly taken. Total area of each leaf blades sample was 0.02 m$^2$. Then the samples were dried in a dryer at 105°C. After drying the leaf blades' surface were determined from the relationship between the surface of disks, and their dry matter:

$$\text{Area of leaf blades'surface } (m^2) = \frac{\text{Leaf blades'dry matter from plant } (g) \times 0.02\ (m^2)}{\text{Dry matter of disk } (g)}$$

The harvest index (HI) was calculated as HI = storage roots' yield / whole plants' yield. Results of roots' yields and their quality has been described in Artyszak et al. [2016b] paper. The yields of storage roots' and leaves' dry matter were calculated as the product of the weighted average of dry weight (including the share of storage roots, leaf blades and petioles of the total biomass) and storage roots' and leaves; yields.

The results were statistically analyzed using the analysis of variance and the Tukeys multiple comparisons tests, with the level of significance α = 0.05. Statistical analyses were performed in the SAS 9.1 program (Cary, USA) using the GLM procedure. Between selected variables correlation coefficients were calculated, to estimate relationships between yield and its quality vs. morphological traits of plants and yields of dry matter. The evaluation of the correlation between the measured traits was calculated using Pearson's correlation coefficients. The significance of correlations was assessed at $P \leq 0.05$ and $P \leq 0.01$.

## RESULTS AND DISCUSSION

Foliar nutrition with marine calcite fertilizer affected in the significant increase of dry matter content in the leaf blades (Table 2). However the effects on the dry matter contents in petioles and storage roots were not observed. Moreover fertilization with marine calcite in second treatment affected in the increase of leaves' dry matter compared to the control and increase the

Table 2. Dry matter and morphological traits of sugar beet related to the treatment application for years 2010–2012

| Year (B) | Treatments of foliar fertilization (A)[1] | | | Mean |
|---|---|---|---|---|
| | 0 | 1 | 2 | |
| Dry matter content in the leaf blades (%) | | | | |
| 2010 | 14.6 | 14.2 | 15.0 | 14.6 |
| 2011 | 14.2 | 17.4 | 16.6 | 16.1 |
| 2012 | 18.7 | 19.6 | 19.6 | 19.3 |
| Mean | 15.8 | 17.1 | 17.1 | – |
| $LSD_{0.05}$: A =1.1; B = 1.1; A/B = 2.0; B/A = 2.0 | | | | |
| Dry matter content in the petioles (%) | | | | |
| 2010 | 9.9 | 9.5 | 9.1 | 9.5 |
| 2011 | 11.9 | 13.4 | 12.2 | 12.5 |
| 2012 | 14.0 | 14.3 | 13.2 | 13.8 |
| Mean | 11.9 | 12.4 | 11.5 | – |
| $LSD_{0.05}$: A = ns; B = 0.5; A/B = 0.9; B/A = 0.9 | | | | |

Table 2. cont.

| | | | | |
|---|---|---|---|---|
| Dry matter content in the storage roots (%) | | | | |
| 2010 | 19.3 | 19.0 | 18.9 | 19.1 |
| 2011 | 24.9 | 24.6 | 24.1 | 24.6 |
| 2012 | 25.5 | 26.7 | 27.6 | 26.6 |
| Mean | 23.2 | 23.4 | 23.6 | – |
| $LSD_{0.05}$: A = ns; B = 0.4; A/B = 0.8; B/A = 0.8 | | | | |
| Dry matter of sugar beet leaf blades per plant (g) | | | | |
| 2010 | 32.7 | 35.2 | 37.7 | 35.2 |
| 2011 | 30.7 | 32.5 | 38.7 | 34.0 |
| 2012 | 22.0 | 22.2 | 23.9 | 22.7 |
| Mean | 28.5 | 30.0 | 33.4 | – |
| $LSD_{0.05}$: A = 4.8; B = 4.8; A/B = ns; B/A = 8.3 | | | | |
| Dry matter of sugar beet petioles per plant (g) | | | | |
| 2010 | 51.1 | 54.4 | 54.1 | 53.2 |
| 2011 | 47.2 | 48.6 | 64.4 | 53.4 |
| 2012 | 28.9 | 31.2 | 30.0 | 30.0 |
| Mean | 42.4 | 44.7 | 49.5 | – |
| $LSD_{0.05}$: A = ns; B = 7.5; A/B = 12.9; B/A = 12.9 | | | | |
| Dry matter of sugar beet storage roots per plant (g) | | | | |
| 2010 | 189 | 201 | 190 | 194 |
| 2011 | 258 | 234 | 280 | 257 |
| 2012 | 256 | 300 | 307 | 288 |
| Mean | 235 | 245 | 259 | – |
| $LSD_{0.05}$: A= ns; B = 46.1; A/B = ns; B/A = 79.9 | | | | |
| Dry matter of sugar beet plants (g) | | | | |
| 2010 | 273 | 291 | 282 | 282 |
| 2011 | 336 | 315 | 383 | 345 |
| 2012 | 307 | 353 | 361 | 341 |
| Mean | 305 | 320 | 342 | – |
| $LSD_{0.05}$: A= ns; B = 51.5; A/B = ns; B/A = ns | | | | |
| Leaves blades' dry matter share in the total dry matter of the plant (%) | | | | |
| 2010 | 11.96 | 12.13 | 13.38 | 12.49 |
| 2011 | 9.24 | 10.43 | 10.12 | 9.93 |
| 2012 | 7.31 | 6.71 | 6.68 | 6.90 |
| Mean | 9.50 | 9.76 | 10.06 | - |
| $LSD_{0.05}$: A = ns; B =1.51; A/B = ns; B/A = 2.62 | | | | |

Table 2. cont.

| | | | | |
|---|---|---|---|---|
| Leaves petioles' dry matter share in the total dry matter of the plant (%) | | | | |
| 2010 | 18.72 | 18.81 | 19.32 | 18.95 |
| 2011 | 14.07 | 15.41 | 16.85 | 15.44 |
| 2012 | 9.11 | 9.38 | 8.46 | 8.99 |
| Mean | 13.97 | 14.54 | 14.88 | - |
| $LSD_{0.05}$: A = ns; B = 1.86; A/B = ns; B/A = 3.22 | | | | |
| Roots' dry matter share in the total dry matter of the plant (%) | | | | |
| 2010 | 69.3 | 69.1 | 67.3 | 68.6 |
| 2011 | 76.7 | 74.2 | 73.0 | 74.6 |
| 2012 | 83.6 | 83.9 | 84.9 | 84.1 |
| Mean | 76.5 | 75.7 | 75.1 | - |
| $LSD_{0.05}$: A = ns; B = 2.98; A/B = ns; B/A = 5.16 | | | | |

ns – no significant differences; [1]treatments according to table 1

number of leaves per each plant compared to the control and first treatment (Table 2 and 3). The tendency of petioles' roots' and whole plants' dry matter increase as the effect of foliar fertilization was also observed. In the another experiments of the same authors [Artyszak et al. 2016a]

Table 3. Number of leaves and their area related to the treatment of foliar application for years 2010–2012

| Year (B) | Treatments of foliar fertilization (A)[1] | | | Mean |
|---|---|---|---|---|
| | 0 | 1 | 2 | |
| Number of leaves (pcs) | | | | |
| 2010 | 24.4 | 26.3 | 28.3 | 26.3 |
| 2011 | 36.9 | 34.5 | 39.4 | 36.9 |
| 2012 | 30.3 | 28.8 | 31.9 | 30.3 |
| Mean | 30.6 | 29.9 | 33.2 | – |
| $LSD_{0.05}$: A = 2.2; B = 2.2; A/B = 3.7; B/A = 3.7 | | | | |
| Area of leaf blades ($m^2$) | | | | |
| 2010 | 0.69 | 0.81 | 0.88 | 0.79 |
| 2011 | 0.58 | 0.59 | 0.79 | 0.65 |
| 2012 | 0.32 | 0.33 | 0.45 | 0.36 |
| Mean | 0.53 | 0.57 | 0.70 | – |
| $LSD_{0.05}$: A = 0.10; B = 0.10; A/B = ns; B/A = ns | | | | |

ns – no significant differences; [1]treatments according to table 1 marine calcite fertilization resulted in the increase tendency of: dry matter of leaf blades, petioles, storage root, and whole plant as well as number and surface area of leaf blades compared with the control treatment. In studies of Tripathi et al. [2012] silicon fertilization of the rice resulted in the increase of the fresh weight of the seedlings' aboveground parts of 74.5 mg to 87.2 mg and of the seedlings roots of 31.3 mg to 35.1 mg compared to control (without silicon fertilization) under chrome toxity. The authors also noticed the higher dry matter of rice plants. For the aboveground parts it was increase of 15.3 to 17.6 mg, and roots of 5.4 to 6.0 mg. At the same time the average height of the seedlings increased of 18.5 to 20.0 cm, and the roots of 9.2 to 9.7 cm. Crusciol et al. [2009] observed in potato experiment that silicon fertilization affected in the significant increase in dry weight of potato tubers per plant of 223.6 to 245.8 g, and the reduction of stems lodging (of 61.1 to 38.6%). However any impact on the mean tuber weight of silicon fertilization was observed. At presented study foliar silicon fertilization had no significant effect on the dry matter share of individual organs in dry matter of the whole plant. Storage root's dry matter share in the total dry matter from plant varied in the range of 67 to 85%. Milford [2006] noticed that weather conditions, especially drought stress at critical stages can cause the proportion of crop's total dry matter allocated to the storage root to vary from 47 to 77%, and the proportion of sugar in storage-root dry matter from 72 to 78%. From the other hand Jaggard and Qi [2006] informed that at Broom's Barn, Suffolk, UK in1978–1990 sugar root dry matter ratio was differentiated of 0.67 to 0.78. It was the effect of variety and solar radiation intensity. Chołuj et al. [2004] have obtained the similar accumulation of plant dry matter (share of the root dry matter was higher than 80%) during drought. In Wyszyński studies [2003] the value was 73–74%. This author explains that small differences in the following research years have shown that the distribution of assimilates in sugar beet plants has a constant rhythm and it is mainly based on plants' water supply but agronomic factors have a minimal effect.

The second treatment of fertilization in presented results affected in the significant increase of the number of leaves and the leaf area compared to the control treatment and to the first treatment. Mikucik and Mikucik [2008] in their experiment with strawberries observed the reaction of strawberry plants to foliar application of potassium – silicon fertilizer. Foliar nutrition did not significantly affected the total size of the assimilation surface of leaves of an individual plant and the surface of an individual leaf. The plants to which foliar nutrition was applied and the control plants were also characterized by a similar number of leaves. Fertilization with marine calcite in presented experiment affected in the significant increase of the dry matter yield of leaves, roots and whole plants compared to the control treatment (Table 4). However the highest yields of leaves' dry matter were noticed as the effect of fertilization with first treatment and the highest yields of the roots' dry matter were noticed as the effect of fertilization with second treatment. Dry matter yields of leaves ranged of 4.75 to 12.42 $t \cdot ha^{-1}$, and of the roots of 14.1 to 24.5 $t \cdot ha^{-1}$, and the total yield of dry matter of 19.5 to 32.0 $t \cdot ha^{-1}$. At Broom's Barn, Suffolk, UK research in 1978–1990 the dry matter yields of leaves ranged of 4.4–7.5 $t \cdot ha^{-1}$, and of roots ranged of 11.2 to 22.9 $t \cdot ha^{-1}$. The yields of the total dry matter ranged of 17.7 to 27.3 $t \cdot ha^{-1}$ [Jaggard and Qi 2006]. Such yields were noticed at the experiments were water irrigation was applied due to the drought stress elimination. In the presented experiment the effect of foliar fertilization on harvest index value was not clear. In the fertilization first treatment HI value was significantly lower compared to the control treatment and fertilization second treatment. Jaggard and Qi [2006] observed that at Broom's Barn, Suffolk, UK in 1978–1990 HI value ranged of 0.46 to 0.59. The authors explained such results as the effect of variety and differentiated solar radiation.

The yields of the storage roots, biological and technological sugar were most strongly correlated with dry matter yield of storage roots and total yield of dry matter (Table 5). Similar cor-

Table 4. Dry matter's yields of sugar beet leaves, roots, and total dry matter of sugar beet plants related to the treatment of foliar application for years 2010–2012

| Year (B) | Treatments of foliar fertilization (A)[1] | | | Mean |
|---|---|---|---|---|
| | 0 | 1 | 2 | |
| Harvest Index | | | | |
| 2010 | 0.60 | 0.52 | 0.59 | 0.57 |
| 2011 | 0.63 | 0.66 | 0.66 | 0.65 |
| 2012 | 0.58 | 0.46 | 0.54 | 0.53 |
| Mean | 0.61 | 0.54 | 0.60 | – |
| $LSD_{0.05}$: A = 0.04; B = 0.04; A/B = 0.07; B/A = 0.07 | | | | |
| Leaves' dry matter yield ($t \cdot ha^{-1}$) | | | | |
| 2010 | 5.38 | 8.41 | 6.36 | 6.72 |
| 2011 | 4.75 | 7.59 | 6.63 | 6.32 |
| 2012 | 7.50 | 12.42 | 9.01 | 9.64 |
| Mean | 5.88 | 9.47 | 7.33 | – |
| $LSD_{0.05}$: A = 0.63; B = 0.63; A/B = 1.09; B/A = 1.09 | | | | |
| Roots' dry matter yield ($t \cdot ha^{-1}$) | | | | |
| 2010 | 14.1 | 16.0 | 15.6 | 15.2 |
| 2011 | 16.3 | 24.5 | 23.3 | 21.4 |
| 2012 | 16.9 | 17.3 | 19.5 | 17.9 |
| Mean | 15.8 | 19.3 | 19.5 | – |
| $LSD_{0.05}$: A = 3.1; B = 3.1; A/B = 5.3; B/A = 5.3 | | | | |
| | Total dry matter yield (leaves + roots) ($t \cdot ha^{-1}$) | | | |
| 2010 | 19.5 | 24.4 | 22.0 | 22.0 |
| 2011 | 21.0 | 32.0 | 30.0 | 27.7 |
| 2012 | 24.4 | 29.8 | 28.5 | 27.6 |
| Mean | 21.6 | 28.7 | 26.8 | – |
| $LSD_{0.05}$: A = 3.3; B = 3.3; A/B = 5.7; B/A = 5.7 | | | | |

ns – no significant differences; [1]treatments according to table 1

Table 5. Correlation coefficients between yield and its quality vs. plant morphological features and dry matter yield for years 2010–2012 (n =12)

| Variablles | | T[1] | Yield ($t \cdot ha^{-1}$) | | | Sucrose, (%) | Content ($mmol \cdot kg^{-1}$) | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | Roots | Biological sugar | Technolo-gical sugar | | Alpha-amine-nitrogen | K | Na |
| Dry matter of (g) | leaf blades | 0 | 0.39 | 0.23 | 0.23 | -0.26 | -0.53* | -0.44 | 0.32 |
| | | 1 | 0.23 | 0.10 | 0.10 | -0.33 | -0.44 | -0.35 | 0.43 |
| | | 2 | 0.67** | 0.49 | 0.48 | -0.07 | -0.69** | -0.73** | 0.47 |
| | petioles | 0 | 0.29 | 0.05 | 0.03 | -0.42 | -0.42 | -0.59** | 0.51* |
| | | 1 | 0.25 | 0.23 | 0.22 | -0.36 | -0.48 | -0.37 | 0.49 |
| | | 2 | 0.75** | 0.63** | 0.63** | 0.09 | -0.82** | -0.90** | 0.29 |
| | root | 0 | -0.01 | 0.28 | 0.30 | 0.52* | 0.15 | 0.31 | -0.58** |
| | | 1 | 0.19 | 0.16 | 0.17 | 0.49 | 0.11 | 0.48 | -0.45 |
| | | 2 | 0.18 | 0.40 | 0.41 | 0.62** | -0.26 | 0.23 | -0.59** |
| | plant | 0 | 0.12 | 0.31 | 0.32 | 0.35 | -0.04 | 0.08 | -0.38 |
| | | 1 | 0.35 | 0.25 | 0.25 | 0.35 | -0.04 | 0.42 | -0.35 |
| | | 2 | 0.43 | 0.60** | 0.60** | 0.63** | -0.52* | -0.07 | -0.47 |
| Share of dry matter (%) | leaf blades | 0 | -0.20 | 0.04 | 0.08 | 0.31 | 0.40 | 0.64* | -0.55 |
| | | 1 | -0.38 | -0.16 | -0.02 | 0.52 | 0.19 | 0.28 | -0.85** |
| | | 2 | -0.31 | -0.06 | 0.08 | 0.40 | 0.10 | 0.45 | -0.82** |
| | petioles | 0 | -0.16 | 0.23 | 0.33 | 0.46 | 0.37 | 0.61* | -0.65* |
| | | 1 | -0.39 | -0.16 | -0.06 | 0.54 | 0.02 | 0.01 | -0.90** |
| | | 2 | -0.14 | 0.12 | 0.22 | 0.54 | 0.17 | 0.41 | -0.88** |
| | roots | 0 | -0.16 | 0.23 | 0.32 | 0.50 | 0.31 | 0.57 | -0.67* |
| | | 1 | -0.52 | -0.29 | -0.19 | 0.44 | 0.22 | 0.17 | -0.85** |
| | | 2 | -0.18 | 0.08 | 0.16 | 0.50 | 0.31 | 0.49 | -0.85** |
| Number of leaves (pcs) | | 0 | -0.08 | 0.34 | 0.40 | 0.78** | -0.39 | 0.05 | -0.71** |
| | | 1 | 0.16 | 0.37 | 0.40 | 0.65** | -0.48 | -0.36 | -0.50* |
| | | 2 | 0.59** | 0.83** | 0.85** | 0.80** | -0.71** | -0.59** | -0.51* |
| Area of leaf blades ($m^2$) | | 0 | 0.34 | 0.11 | 0.11 | -0.39 | -0.59** | -0.60** | 0.51* |
| | | 1 | 0.32 | 0.10 | 0.08 | -0.56* | -0.31 | -0.21 | 0.69** |
| | | 2 | 0.53* | 0.26 | 0.25 | -0.32 | -0.52 | -0.62** | 0.64** |
| Harvest index | | 0 | 0.69* | 0.72** | 0.73** | 0.17 | -0.32 | -0.32 | 0.04 |
| | | 1 | 0.85** | 0.90** | 0.87** | 0.50 | -0.81** | -0.13 | 0.36 |
| | | 2 | 0.99** | 0.92** | 0.84** | 0.46 | -0.48 | -0.73** | 0.36 |

Table 5. cont.

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Yield of dry matter (t·ha$^{-1}$) | leaves | 0 | 0.18 | 0.29 | 0.27 | -0.06 | 0.69* | 0.62* | -0.31 |
| | | 1 | -0.46 | -0.41 | -0.35 | -0.08 | 0.62* | 0.41 | -0.59* |
| | | 2 | -0.64* | -0.48 | -0.35 | 0.06 | 0.42 | 0.62* | -0.75** |
| | roots | 0 | 0.81** | 0.99** | 0.98** | 0.24 | 0.06 | -0.03 | -0.27 |
| | | 1 | 0.75** | 0.88** | 0.91** | 0.73** | -0.59* | 0.15 | -0.09 |
| | | 2 | 0.65* | 0.83** | 0.87** | 0.75** | -0.32 | -0.26 | -0.37 |
| | total | 0 | 0.80** | 0.98** | 0.97** | 0.22 | 0.09 | 0.01 | -0.27 |
| | | 1 | 0.75** | 0.88** | 0.91** | 0.73** | -0.59* | 0.15 | -0.09 |
| | | 2 | 0.65* | 0.83** | 0.87** | 0.75** | -0.32 | -0.26 | -0.37 |

**, * significant correlation at $p \leq 0.01$ and 0.05; T[1] - treatments according to table 1

relations for yields of: storage roots, biological and technological sugar and HI were observed. The dry matter of petioles was positively correlated with the yields of: storage roots, biological and technological sugar, but in the second treatment only. Similarly the second treatment affected in positive correlation between number of leaves and yields of storage roots, biological and technological sugar. Bergen [1967] described the positive correlation of petioles dry matter content with sucrose content in roots and negative correlation of petioles dry matter content with matter of root at the same time. Sugar content was the most strongly determined by the number of leaves. Quite a large number of leaves per plants may indicate efficient transport of carbohydrates from the leaves to the roots. In another experiments of the same authors [Artyszak et al. 2016a] storage root yield was significantly correlated with dry matter of petioles and their share in dry matter of plant and negatively with the share of root dry matter in dry matter of plant. At the same time a significant positive correlation of technological and biological sugar yield, with share of petioles dry matter in the total dry matter of whole plant and negative correlation with share of root dry matter in total dry matter of plant.

## CONCLUSIONS

1. Foliar fertilization with marine calcite has the beneficial effect mainly on such features like: dry matter content in the leaf blades, dry matter of leaf blades, area of the leaf blades, and the number of leaves per single sugar beet plants.
2. Application of marine calcite foliar fertilization significantly increase the dry matter yields of leaves, roots and whole plants compared to the control.
3. Storage roots' yield, biological and technological sugar yields are significantly correlated with harvest index. Sugar content in storage roots is positively correlated with the number of leaves.

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**WPŁYW DOKARMIANIA DOLISTNEGO KALCYTEM MORSKIM NA CECHY MORFOLOGICZNE BURAKA CUKROWEGO**

**Synopsis**. W doświadczeniu polowym przeprowadzonym w latach 2010–2012, w południowo-wschodniej Polsce, w Sahryniu (50°41′ N, 23°46′ E) oceniano wpływ dokarmiania dolistnego kalcytem morskim na cechy morfologiczne roślin buraka cukrowego, odmiany Britannia. Kalcyt morski stosowano w 3 wariantach: 0) kontrola – bez dokarmiania dolistnego; 1) Herbagreen 1 $kg \cdot ha^{-1}$ (stadium 4–6 liści) oraz Herbagreen 2 $kg \cdot ha^{-1}$ (po trzech tygodniach); 2) Herbagreen 2 $kg \cdot ha^{-1}$ (stadium 4–6 liści) oraz Herbagreen 2 $kg \cdot ha^{-1}$ (po trzech tygodniach). Stosowanie dolistne kalcytu morskiego miało istotnie korzystny wpływ na takie cechy jak: zawartość suchej masy w blaszkach liściowych, suchą masę i powierzchnię blaszek liściowych oraz liczbę liści na roślinie. W doświadczeniu zaobserwowano również tendencję do większego gromadzenia suchej masy w ogonkach i korzeniach pod wpływem dokarmiania dolistnego. We wszystkich wariantach plon korzeni, plon biologiczny i technologiczny cukru były istotnie dodatnio skorelowane z splonem suchej masy korzeni, łącznym plonem suchej masy (korzenie + liście) oraz współczynnikiem plonowania rolniczego (HI). Natomiast związek plonu korzeni, plonu biologicznego i technologicznego cukru z suchą masą ogonków liściowych oraz z liczbą liści był istotny tylko w wariancie drugim. Ponadto we wszystkich wariantach zawartość cukru w korzeniach była istotnie dodatnio skorelowana z liczbą liści pojedynczej rośliny.

**Słowa kluczowe**: dokarmianie dolistne, krzem, morfologia liścia, współczynnik plonowania rolniczego

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