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# THE EFFECT OF FOLIAR NUTRITION WITH UREA, MOLYBDENUM, SUCROSE AND BENZYLADENINE ON QUANTITY AND QUALITY OF RADISH YIELD

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**Abstract**. In the years 2006–2007 radish 'Opolanka' cv. was grown in 60 × 40 × 20 cm containers, placed in the open field under a shade providing fabric. A loamy clay soil was used as a substrate. The following foliar nutrition treatments were applied twice: 1 – control (spray with water), 2 – urea, 3 – urea + Mo, 4 – urea + Mo + BA, 5 – urea + Mo + BA + sucrose, 6 – BA (benzyladenine) and 7 – sucrose. There were used the following concentrations of tested compounds: urea 20 $g \cdot dm^{-3}$, sucrose 10 $g \cdot dm^{-3}$, molybdenum (Mo) 1 $mg \cdot dm^{-3}$ and BA 5 $mg \cdot dm^{-3}$. Foliar nutrition treatments had a significant effect on average mass of plant leaves and on concentration of soluble sugars and ascorbic acid in radish roots. Plants treated with a mixture of urea + Mo + BA + sucrose featured the highest average mass of plant leaves. Radish roots of control plants and those sprayed solely with BA contained significantly more soluble sugars than roots of plants from other treatments. Spraying the plants with solutions containing only sucrose or only BA (treatments: 6 and 7) caused a significant reduction of ascorbic acid content in radish roots in comparison to other treatments. All the solutions used for foliar nutrition had no effect on radish roots mass and on mass of whole plants (roots + leaves). There were also not observed any significant changes in dry matter content of leaves and roots likewise in the content of phenolic compounds, phenylpropanoids, flavonols or anthocyanins in radish roots.

**Key words**: radish, soluble sugars, ascorbic acid, phenolic compounds, phenylpropanoids, flavonols, anthocyanins

## INTRODUCTION

Nutritional value of vegetables depends, apart from others, on the content of compounds with antioxidant properties such as: ascorbic acid, phenolic compounds, phenylpropanoids, flavonols and anthocyanins [Mareczek and Leja 2005, Leja et al. 2005]. Concentrations of those compounds in plant may be modified by various factors including foliar nutrition with biogenic components.

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Among all micro- and macroelements, nitrogen in urea form is the fastest-assimilated nutritional component by plant leaves. Moreover, urea causes hydration of cuticle what facilitates the assimilation of urea itself as well as other compounds supplied in the process of foliar nutrition [Marschner 1995, Michałojć and Szewczuk 2003]. Amid nitrogen ($N\text{-}NH_2$) contained in urea is not directly included in the metabolic route of this component in plants. The enzyme urease is responsible for hydrolysis of urea which results in the production of ammonium nitrogen ($N\text{-}NH_4$), which is further incorporated into simple organic compounds [Marschner 1995].

Molybdenum (Mo) is an essential trace element for most organisms as it occurs in more than 60 enzymes catalyzing diverse oxidation–reduction reactions. This element has a crucial role in plant nitrogen metabolism being involved in the processes of $N_2$ fixation, nitrate reduction, and the transport of nitrogen in plants [Marschner 1995, Hamlin 2007].

Benzyladenine (BA) is a synthetic cytokinin. Physiological role of this group of growth regulators is connected, apart from others, with the stimulation of cell division, retardation of senescence or regulation of biochemical processes through affetcting enzyme activity [Borkowska 1997]. In research presented by Smoleń and Sady [2005] foliar application of BA (in 5 and 10 $mg \cdot dm^{-3}$ concentrations) caused an increase in yield and concentration of soluble sugars as well as decreased the nitrate level in carrot storage roots. Pogroszewska et al. [2007] found that BA in the concentration of 500 $mg \cdot dm^{-3}$ applied for pre-planting soaking of anions or for spraying plants in green bud phase resulted in the increase in onion yield (*Allium karataviense* Regel.) 'Ivory Queen'. Research conducted by Kano and Fukuoka [1996] proved that the synthesis of endogenous cytokinins, as well as their effective activity in the roots of Japanese radish depended on soil temperature and plant cultivar. In general, the level of cytokinin activity in roots was lowered when plants were grown under high temperature conditions. Moreover, the production of endogenous cytokinin in the roots of cultivars susceptible to hollowness ('Sobuto' and 'Fukumi'), was reduced at higher soil temperatures, while in resistant cultivars cytokinin production was higher.

Starck [2003] reveals that sugars play the role of signal substances acting in cells or between organs and indirectly transmitting information about the level of reserves and demand of individual structures for the products of photosynthesis. Sugars together with hormones participate in the transduction of signals on the level of gene expression. Hara et al. [2003] suggested that endogenous sugars transported into hypocotyls promote anthocyanin production by inducing expression of the biosynthetic genes in radish seedlings cv 'Comet'. Moreover, these authors demonstrated that under *in vitro* conditions detached hypocotyls of radish seedlings produced large amounts of anthocyanins using exogenous glucose, fructose, or sucrose, but little anthocyanin using mannose or 3-*O*--methyl-*D*-glucose. In these investigation, treatment with 175 mM sucrose was the most effective in inducing anthocyanin biosynthesis in the hypocotyl system. According to Jain and Guruprasad [1989] chlorocholine chloride (CCC) promotes and $GA_3$ inhibits the synthesis of anthocyanin in radish seedlings cv. 'Scarlet Globe'. What is more, when both substances are applied together, CCC reverses the inhibition caused by $GA_3$. Similar effect was observed after simultaneous external feeding of anthocyanin precursors (sucrose and phenylalanine). In the literature available to the authors there is no information on the effect of phytohormones from cytokinins group (benzyladenine) or their conjoined application in foliar nutrition on the synthesis of anthocyanins in radish.

This research was aimed at the examination of the effect of exogenous cytokinin (benzyladenine) combined with foliar nutrition with urea, molybdenum and sucrose on the yield and content of dry matter, soluble sugars, ascorbic acid, phenolic compounds, phenylpropanoids, flavonols and anthocyanins in radish roots.

## MATERIAL AND METHODS

Radish 'Opolanka' cv. was cultivated in the 2006–2007 in open-work containers sized 60 × 40 × 20 cm, placed in the open field under a shade providing fabric. The containers were filled with silt loam (35% sand, 28% silt and 37% clay) with mean content of organic matter 2.52 % and the following concentrations of the available nutrient forms soluble in 0.03 M acetic acid: N ($N\text{-}NO_3$ + $N\text{-}NH_4$) 14.9 mg, P 73.8 mg, K 92.4 mg, Mg 159.8 mg and Ca 1299.0 mg in 1 $dm^{-3}$ soil. Soil reaction $pH_{(H_2O)}$ was 6.88 and $pH_{(KCl)}$ 6.20, while general concentration of salt in soil (EC) 0.15 EC $mS\cdot cm^{-1}$.

The following combinations of experiments were arranged: 1 – control without foliar nutrition and foliar nutrition with: 2 – urea, 3 – urea + Mo, 4 – urea + Mo + BA, 5 – urea + Mo + BA + sucrose, 6 – BA and 7 – sucrose. In combinations 2 – 7, following concentrations of components in solution were applied: urea 20 $g\cdot dm^{-3}$, sucrose 10 $g\cdot dm^{-3}$, molybden 1 $mg\cdot dm^{-3}$, benzyladenine 5 $mg\cdot dm^{-3}$. Plants in individual experiment combinations were sprayed twice. First treatment was conducted in the phase of two developed leaves and the second one in the phase of three – four shaping specific leaves on 24.05 and 01.06 2006 and 14.05 and 17.05 2007, respectively.

The experiment was arranged in the randomized complete blocks design with three replicates per treatment. Each replicate (container) consisted of 5 rows with 25 seeds per row. Seeds sowing were performed on 04.05.2006 and 11.04.2007. After germination plants were singled out leaving 12 seedlings in one row. Before cultivation the content of nitrogen and potassium in soil was supplemented to the level 100 $mg\cdot dm^{-3}$ of soil with the use of solid fertilizers of ammonium nitrate and potassium sulphate. Harvesting combined with yield assessment and collecting samples of edible radish roots (henceforth referred to as roots) and leaves was performed on 07.06.2006 and 22.05.2007. Only roots suitable for consumption were selected for further analysis. Their mass was 3.0–7.6 g per root, an average number of roots from one container (replicate) was 42.

Dry matter content was assessed in radish leaves and roots at 105°C. The content of total soluble sugars in radish roots was determined by the anthrone method. The content of ascorbic acid was determined in extracts prepared with oxalic acid by titration of potassium iodide [Duliński et. al. 1988]. To estimate phenolic constituents in radish roots extracts in 80% methanol were prepared. Total phenols, phenylpropanoids, flavonols and anthocyanins concentrations were determined by the spectrophotometric method proposed by Fakumoto and Mazza [2000]. Chlorogenic acid, caffeic acid and quercetin were used as the standards for total phenols, phenylpropanoids and flavonols, respectively. Anthocyanin content was expressed as the cyanidin, according to its molar extinction.

Prior to the experiment, granulometric composition of soil was assessed using Casagrande method modified by Pruszyński, organic matter concentration was determined using Tiurin method modified by Oleksynowa. Soil $pH_{(H2O)}$ and $pH_{(KCl)}$ were assessed by potentiometer, total concentration of salt in soil EC was measured conductometrically and the content of: $N\text{-}NH_4$, $N\text{-}NO_3$, P, K, Mg, Ca after extraction 0.03M $CH_3COOH$ [Nowosielski 1988]. Nitrogen was assessed with the use of microdistillation method while K, Mg, Ca by AAS method, and P with the use of vanadium-molybdenum method [Ostrowska et al. 1991].

Obtained results were statistically verified by ANOVA module of Statistica 7.1 PL programme for significance level $P < 0.05$. Changes of any significance were assessed with the use of variance analysis. In case of changes significance homogenous groups were determined on the basis of Duncan test.

## RESULTS AND DISCUSSION

Usuda et al. [1999a, b] proved that sucrose synthase (*SuSy*) rather than invertase may be crucial for the development of the sink activity of the radish storage root and that reaction products of UDP-glucose and fructose are utilized for sink growth including biosynthesis of cell walls. These authors' investigation revealed differences within capability to accumulate dry matter in leaves and storage root between radish cultivars with low and high storage root:shoot ratio. Dry matter content in roots on 21$^{st}$ day after sowing was 3% and 50% respectively for cultivars with low and high storage root:shoot ratio. Usuda et al. [1999a] also reported that mechanisms of control sink capacity are poorly understood. In radish, a major sink is the storage root, which begins to thicken early in development, mainly as a result of thickening of the hypocotyl. Investigations by Rouhier and Usuda [2001] confirmed that *SuSy* is a key enzyme in the development of radish storage root, especially between 11$^{th}$ and 13$^{th}$ day after sowing when thickening growth of hypocotyls occurs. In our research, combinations of solutions applied for foliar nutrition significantly influenced leaves weight (tab. 1 – mean from 2006–2007). However, they did not cause any considerable changes in roots weight as well as the mass of all radish plant /leaves + root/ (tab. 1). They also did not affect the content of dry matter in leaves and roots (tab. 2). Results of presented research differ from the results of previous experiments with carrot cultivation [Smoleń and Sady 2005], where foliar nutrition with the combination of urea + Mo + BA + sucrose increased the content of dry matter in carrot storage roots. Mean from 2006–2007 of our experiments proved that the highest leaves weight in plants with foliar nutrition (combination of urea+Mo+BA+sucrose), was on the same level (the same homogenous group) as plants sprayed with solutions of: urea + Mo, urea + Mo + BA, BA and sucrose. It should be noted that in those four combinations leaves weight did not statistically differ from the lowest leaves weight which characterized the control plants.

The results of laboratory analyses indicate that foliar nutrition treatment significantly influenced the content of ascorbic acid and soluble sugars in radish roots (tab. 2 – results for 2007 and mean from 2006–2007). Plant spraying with solutions containing solely sucrose or BA (combinations 6 and 7) resulted in considerable decrease of ascorbic acid content in roots when compared with other treatments. In literature there is no information unambiguously explaining the reasons for the decrease in ascorbic acid content after plant spraying with sucrose or BA only.

Roots of control plants and plants sprayed only with BA contained more soluble sugars than plants from other experimental combinations (tab. 2, average from 2006–2007 and partly results for 2007). In earlier research, Smoleń and Sady [2005] reported that double plant spraying only with BA (in concentration of 5 and 10 $mg \cdot dm^{-3}$) as well as foliar nutrition with the solution of urea + Mo + BA + sucrose (in concentration: urea and sucrose 2%, Mo 1 $mg \cdot dm^{-3}$, BA 5 $mg \cdot dm^{-3}$) caused an elevated level of soluble sugars in carrot storage roots, in comparison to the control without foliar nutrition. Results presented in this work showed that foliar nutrition solely with urea decreased the content of soluble sugars in carrot storage roots as compared to the control without foliar nutrition. Similar effect of plant foliar nutrition with urea on the content of soluble sugars in yield was obtained by Smoleń and Sady [2005] in carrot cultivation and by Rydz [2001], as well as Rożek and Wojciechowska [2005] in broccoli cultivation. Yet in case of broccoli cultivation, the effect of urea foliar nutrition on sugars concentration in yield was also dependent on the dose of nitrogen applied to the soil and climatic conditions during cultivation.

Smoleń and Sady [2005] showed that plant spraying with the mixture of urea+Mo+BA+sucrose resulted in an increased content of carotenoids in carrot storage roots. In research presented by Hara et al. [2003] under *in vitro* condition, two anthocyanin bio-synthetic genes, chalcone synthase and anthocyanidin synthase, were significantly activated by exogenous sucrose (175 mM), whereas in the control these genes were expressed weakly. Moreover investigations conducted by these authors suggested that endogenous sugars transported into hypocotyls promote anthocyanin bio-synthesis as a result of inducing expression several biosynthetic genes in radish. However, in our experiments none of the solutions applied had any significant influence on the content of anthocyanins as well as phenolic compounds, phenylpropanoids and flavonols in radish roots (tab. 3). The lack of effect of sucrose on the increase in anthocyanins content in radish may result from the fact that sucrose solution used for foliar nutrition in our experiments was six times lower than in the research by Hara et al. [2003]. Furthermore, these authors conducted their experiments under *in vitro* conditions, where the effect of sugar (contained in culture medium) on hypocotyls lasted longer than in our experiments.

Obtained results indicate that foliar nutrition, with urea only in particular, did not have any significant influence on the content of phenolic compounds in radish (tab. 3). In this aspect our results differ from other authors' investigatios. In carrot cultivation [Smoleń and Sady 2005] and in broccoli cultivation (depending on nitrogen dose applied to soil) [Mareczek and Leja 2005, Rożek and Wojciechowska 2005] foliar nutrition with urea exclusively led to an increased level of phenolic compounds in yield.

Lack of effect of all treatments (with solution containing sucrose in particular) on yield level (of radish roots and whole plant), the content of dry matter (in leaves and roots) as well as on the concentration of anthocyanins, phenolic compounds, phenylpropanoids and flavonols in radish roots may result from harvesting radish on 6$^{th}$ and 5$^{th}$ day (for 2006 and 2005 respectively) after second spraying. This period could have been

Table 1. The radish yield presented as average mass of a single radish root and mass of leaves from one plant in years 2006 and 2007
Tabela 1. Plon rzodkiewki przedstawiony jako masa pojedynczego zgrubienia oraz masa liści z jednej rośliny w latach 2006 i 2007

| Combinations Kombinacje | Mass (g) – Masa (g) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | of root – zgrubienia | | | of leaves – liści | | | of a whole plant (leaves + root) całej rośliny (liście + zgrubienie) | | |
| | 2006 | 2007 | mean średnio | 2006 | 2007 | mean średnio | 2006 | 2007 | mean średnio |
| 1. Control – Kontrola | 3.72 a | 3.64 a | 3.68 a | 6.88 a | 3.71 a | 5.29 a | 10.60 a | 7.35 a | 8.97` a |
| 2. Urea – Mocznik | 3.47 a | 4.33 a | 3.90 a | 6.69 a | 4.02 a | 5.35 a | 10.16 a | 8.35 a | 9.25 a |
| 3. Urea + Mo Mocznik + Mo | 4.50 a | 3.91 a | 4.20 a | 7.29 a | 4.17 a | 5.73 ab | 11.79 a | 8.08 a | 9.93 a |
| 4. Urea + Mo + BA Mocznik + Mo + BA | 3.34 a | 3.45 a | 3.39 a | 7.40 a | 4.07 a | 5.73 ab | 10.73 a | 7.52 a | 9.12 a |
| 5. Urea + Mo + BA + sucrose Mocznik + Mo + BA + sacharoza | 3.29 a | 3.08 a | 3.18 a | 9.98 a | 3.98 a | 6.98 b | 13.26 a | 7.06 a | 10.16 a |
| 6. BA | 3.57 a | 3.71 a | 3.64 a | 6.82 a | 4.36 a | 5.59 ab | 10.39 a | 8.08 a | 9.23 a |
| 7. Sucrose – Sacharoza | 4.14 a | 4.95 a | 4.54 a | 7.08 a | 4.31 a | 5.69 ab | 11.22 a | 9.26 a | 10.24 a |

Means followed by the same letters are not significantly different for $P < 0.05$
Średnie oznaczone tymi samymi literami nie różnią się istotnie dla $p < 0,05$

Table 2. The content of dry matter in radish leaves and roots as well as the content of soluble sugars and ascorbic acid in radish roots in years 2006 and 2007

Tabela 2. Zawartość suchej masy w liściach i zgrubieniach rzodkiewki oraz zawartość cukrów rozpuszczalnych i kwasu askorbinowego w zgrubieniach rzodkiewki w latach 2006 i 2007

| Combinations<br>Kombinacje | Dry matter (% d.m.) – Sucha masa (% s.m.) | | | | | | Soluble sugars ($mg·100 g^{-1}$ f.w.)<br>Cukry rozpuszczalne ($mg·100 g^{-1}$ św.m.) | | | Ascorbic acid ($mg·100 g^{-1}$ f.w.)<br>Kwas askorbinowy ($mg·100 g^{-1}$ św.m.) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | in leaves – w liściach | | | in roots – zgrubieniach | | | | | | | | |
| | 2006 | 2007 | mean<br>średnio | 2006 | 2007 | mean<br>średnio | 2006 | 2007 | mean<br>średnio | 2006 | 2007 | mean<br>średnio |
| 1. Control – Kontrola | 8.96 a | 9.66 a | 9.31 a | 4.27 a | 4.77 a | 4.52 a | 1365.8 a | 1567.0 c | 1466.4 b | 29.5 a | 24.0 b | 26.7 bc |
| 2. Urea – Mocznik | 8.56 a | 9.88 a | 9.22 a | 4.16 a | 4.54 a | 4.35 a | 1148.7 a | 1394.4 abc | 1271.5 a | 30.8 a | 23.8 b | 27.3 bc |
| 3. Urea + Mo<br>Mocznik + Mo | 8.98 a | 9.53 a | 9.25 a | 4.08 a | 4.35 a | 4.21 a | 1163.8 a | 1294.0 a | 1228.9 a | 29.0 a | 27.1 c | 28.0 c |
| 4. Urea + Mo + BA<br>Mocznik + Mo + BA | 8.76 a | 9.66 a | 9.21 a | 4.18 a | 4.58 a | 4.38 a | 1192.4 a | 1360.6 ab | 1276.5 a | 28.6 a | 23.5 b | 26.0 b |
| 5. Urea + Mo + BA + sucrose<br>Mocznik + Mo + BA + sacharoza | 8.56 a | 10.02 a | 9.29 a | 4.28 a | 4.89 a | 4.58 a | 1083.1 a | 1464.4 abc | 1273.7 a | 31.7 a | 22.2 b | 26.9 bc |
| 6. BA | 9.33 a | 9.81 a | 9.57 a | 4.29 a | 4.60 a | 4.44 a | 1357.4 a | 1525.3 bc | 1441.3 b | 27.3 a | 18.9 a | 23.1 a |
| 7. Sucrose – Sacharoza | 8.96 a | 9.74 a | 9.35 a | 4.27 a | 4.40 a | 4.33 a | 1285.0 a | 1298.5 a | 1291.7 a | 26.8 a | 18.7 a | 22.8 a |

Means followed by the same letters are not significantly different for $P < 0.05$
Średnie oznaczone tymi samymi literami nie różnią się istotnie dla $p < 0,05$

Table 3. The content of phenolic compounds, phenylpropanoids, flavonols and anthocyanins in radish roots in years 2006 and 2007
Tabela 3. Zawartość związków fenolowych, fenylopropanoidów, flawonoli i antocyjanów w zgrubieniach rzodkiewki w latach 2006 i 2007

| Combinations<br>Kombinacje | (mg·100 $g^{-1}$ f.w.) – (mg·100 $g^{-1}$ św.m.) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | phenolic compounds<br>związki fenolowe | | | phenylpropanoids<br>fenylopropanoidy | | | flavonols<br>flawonole | | | anthocyanins<br>antocyjany | | |
| | 2006 | 2007 | mean<br>średnio | 2006 | 2007 | mean<br>średnio | 2006 | 2007 | mean<br>średnio | 2006 | 2007 | mean<br>średnio |
| 1. Control – Kontrola | 106.7 a | 96.5 a | 101.6 a | 21.7 a | 19.1 a | 20.4 a | 13.0 a | 9.9 a | 11.4 a | 31.4 a | 30.6 a | 31.0 a |
| 2. Urea – Mocznik | 111.2 a | 119.0 a | 115.1 a | 22.7 a | 24.3 a | 23.5 a | 13.2 a | 12.5 a | 12.8 a | 33.4 a | 39.8 a | 36.6 a |
| 3. Urea + Mo – Mocznik + Mo | 110.9 a | 107.4 a | 109.1 a | 22.8 a | 21.6 a | 22.2 a | 11.5 a | 11.0 a | 11.2 a | 34.9 a | 35.3 a | 35.1 a |
| 4. Urea + Mo + BA<br>Mocznik + Mo + BA | 118.2 a | 113.9 a | 116.0 a | 24.7 a | 23.4 a | 24.0 a | 14.0 a | 11.8 a | 12.9 a | 37.1 a | 39.1 a | 38.1 a |
| 5. Urea + Mo + BA + sucrose<br>Mocznik + Mo + BA + sacharoza | 108.5 a | 109.5 a | 109.0 a | 21.9 a | 21.9 a | 21.9 a | 11.6 a | 11.1 a | 11.3 a | 33.2 a | 35.7 a | 34.4 a |
| 6. BA | 104.7 a | 110.6 a | 107.6 a | 22.2 a | 22.7 a | 22.4 a | 11.2 a | 11.3 a | 11.2 a | 35.5 a | 35.0 a | 35.2 a |
| 7. Sucrose – Sacharoza | 112.1 a | 107.5 a | 109.8 a | 23.3 a | 21.9 a | 22.6 a | 12.9 a | 10.7 a | 11.8 a | 36.7 a | 35.2 a | 35.9 a |

Means followed by the same letters are not significantly different for $P < 0.05$
Średnie oznaczone tymi samymi literami nie różnią się istotnie dla $p < 0,05$

too short for all applied compounds to efficiently shape the quantity and biological value of radish yield. Too low concentration of sucrose (1%) in the solutions might have been an additional factor reducing the effect of foliar nutrition with sucrose on the quantity and quality of the yield. It should be emphasized that sucrose intake by leaves takes place through cuticle pores [Marschner 1995]. The gradient of sucrose concentration (electrochemical potential) between plant tissue and working liquid is one of the major factors influencing possibility and rate of plant intake of this compound. As Starck [2003] informs, the content of sucrose in plant leaves is between 10–50 mM (0.34–1.71%). According to other authors, plant foliar nutrition with sucrose solutions in concentrations higher than 5% in radish [Kováčik 1999] or 2% in carrot cultivation [Smoleń and Sady 2005] significantly influences biological quality and quantity of these plants yield.

## CONCLUSIONS

The highest leaves mass was observed in combination with urea + Mo + BA + sucrose application and the lowest in the control. Solutions applied for foliar nutrition did not influence roots mass and radish total plant mass (leaves + root).

The roots of control plants and of those sprayed only with BA were characterized by significantly higher content of soluble sugars than roots of plants from other combinations.

In comparison with other combinations, radish roots of plant sprayed solely with sucrose or BA contained significantly less ascorbic acid.

Plant spraying with individual solutions did not have any significant effect on the content of dry matter in leaves and root, as well as the content of phenolic compounds, phenylpropanoids, flavonols and anthocyanins in radish roots.

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## WPŁYW DOKARMIANIA DOLISTNEGO MOCZNIKIEM, MOLIBDENEM, SACHAROZĄ I BENZYLOADENINĄ NA WIELKOŚĆ I JAKOŚĆ PLONU RZODKIEWKI

**Streszczenie**. Rzodkiewkę 'Opolanka' uprawiano w latach 2006–2007 w pojemnikach o wymiarach 60 × 40 × 20 cm wypełnionych glebą gliniastą, umieszczonych na terenie otwartym pod cieniówką. Dwukrotne dokarmianie dolistne roślin wykonano przy użyciu następujących roztworów: 1 – kontrola (oprysk wodą), 2 – mocznik, 3 – mocznik + Mo, 4 – mocznik + Mo + BA, 5 – mocznik + Mo + BA + sacharoza, 6 – BA i 7 – sacharoza. Zastosowano następujące stężenia składników: mocznik 20 $g \cdot dm^{-3}$, sacharoza 10 $g \cdot dm^{-3}$, Mo 1 $mg \cdot dm^{-3}$, BA 5 $mg \cdot dm^{-3}$. Dokarmianie dolistne w istotny sposób wpłynęło na średnią masę liści roślin oraz zawartość cukrów rozpuszczalnych i kwasu askorbinowego w zgrubieniach rzodkiewki. Najwyższą masę liści stwierdzono u roślin dokarmianych dolistnie mieszaniną mocznika + Mo + BA + sacharozy, a najniższą w kontroli. Zgrubienia roślin kontrolnych oraz opryskiwanych samą BA zawierały istotnie więcej cukrów rozpuszczalnych niż zgrubienia z pozostałych obiektów doświadczenia. Opryskiwanie roślin roztworami zawierającymi samą sacharozę oraz samą BA (obiekty nr 6 i 7) powodowało istotne obniżenie zawartości kwasu askorbinowego w zgrubieniach rzodkiewki w porównaniu do pozostałych badanych kombinacji. Roztwory zastosowane do dokarmiania dolistnego nie wpłynęły na masę zgrubień ani na całkowitą masę rośliny (masę zgrubień + masa liści). Nie stwierdzono również istotnych zmian w zawartości suchej masy w liściach i zgrubieniach ani w zawartości związków fenolowych, fenylopropanoidów, flawonoli i antocyjanów w zgrubieniach rzodkiewki.

**Słowa kluczowe**: rzodkiewka, cukry rozpuszczalne, kwas askorbinowy, związki fenolowe, fenylopropanoidy, flawonole, antocyjany

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