**Janina Gajc-Wolska*, Katarzyna Kowalczyk, Mariola Nowecka, Katarzyna Mazur, Agata Metera**

Warsaw University of Life Sciences – SGGW
Faculty of Horticulture and Landscape Architecture
**Department of Vegetable and Medicinal Plants**
Nowoursynowska 159, Warsaw
http://krwil.sggw.pl
* ✉ janina_gajc_wolska@sggw.pl

# EFFECT OF ORGANIC-MINERAL FERTILIZERS ON THE YIELD AND QUALITY OF ENDIVE (*CICHORIUM ENDIVIA* L.)

## INTRODUCTION

**Endive (*Cichorium endivia* L.) is a leaf vegetable of the *Asteraceae* family, nearly unknown in Poland, originating from the eastern region of India. Cultivated forms of that species probably originate from *Cichorium pumilum,* a wild ancestor commonly inhabitating the Mediterranean regions. Endive is the species widely spread in the west and south of Europe. Its popularity is achieved due to it is nutritional value and bitter taste resulting from the presence of sesquiterpene lactones.**

**The usable part of endive is the leaf rosette. There are two botanic cultivars within that species which differ in leaf anatomical structure – escariole (*Cichorium endivia* L. var. latifolium) with smooth, wide leaves of smooth-margins and crispum endive (*Cichorium endivia* L. var. *crispum*) with elongated and strongly frayed leaves.**

**Preparations stimulating plant growth and development commonly called biostimulators are applied in modern horticulture in the whole world. In Poland they are registered as organic-mineral fertilizers. These preparations are obtained from fishes and plant products, e.g. waterweeds. Apart from organic components they also contain mineral components. Out of 2000 species of brown algae the most commonly applied in agriculture are *Ascophyllum nodosum*, *Fucus* spp., *Laminaria* spp., *Sargassum* spp. and *Turbinaria* spp. They are used as a source of organic matter, nutritional components, as components of biostimulators and biofertilizers. Extracts from algae show their activity even in solutions diluted to 1:1000. Some organic-mineral fertilizers are recommended to be applied together with other fertilizers, others should be used instead of mineral fertilizers. Preparations on the basis of algae are destined to be applied both on the leaves and into the soil. They positively affect physico-chemical and biological properties of the soil, favour the development of soil microorganisms and mycorrhizal fungi. They improve the growth and development of the root system facilitating the intake of water and mineral components and causing the increase of the leaf surface and the increase of the intensity and efficiency of photosynthesis which affect results in a plant resistance to stress.**

**The aim of the present investigation was the determination of the effect of the term of cultivation and the application of mineral-organic fertilizers on yielding and chemical composition of the leaf rosettes of the chosen cultivars of endive (*Cichorium endivia* L.).**

## MATERIAL AND METHODS

**The 'Excel' cultivar of escariole and 'Cigal' cultivar of crispum endive destined to all-year round cultivation were used in the present experiment. During the growth of plants two preparations – Goëmar Goteo and Aminoplant were applied. The experiment was carried out on the experimental field in Wilanów-Zawady in the years 2008 and 2009 in the spring (I), summer (II) and winter (III) term. Endive seeds were sown to multipots filled with the mixture of the high moor peat and bark in the glasshouse. The seedlings were planted at the 35×35 cm distance. Field experiment was established in the random blocks system in three replications of 12 plants each.**

**The determination of the weight loss after drying was performed by the dryier method at the temperature of 105°C, results were presented in the mass fraction [%]. The content of nitrates ($NO^{3-}$) was determined with the help of a spectrophotometer Tecator Fiastar 5010 with the wavelength 540 nm, results were presented in mg×100 $g^{-1}$ of fresh matter. The content of phosphorus (P) was determined using the spectrophotometer Shimadzu 1700 with the wavelength 460 nm, and the results were presented in mg×100 $g^{-1}$ of fresh matter Potassium (K) and calcium (Ca) contents were determined using the flame spectrophotometer Scherwood Model 410 and the results are presented in mg×100 $g^{-1}$ of fresh matter. The content of phenolic acids and flavonoids were determined using the HPLC method and the results are presented in mg×100 $g^{-1}$ of dry matter.**

**The obtained results were analysed statistically with the three factor analysis of variance at the significance level of a=0,05 (programme ANOVA 3 and ANOVA 2). The comparison of means was done using the Tukey's test.**

## ACKNOWLEDGMENTS

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## RESULTS

**Table 1. Marketable yield and mean weight of endive rosettes (mean 2008-2009)**

| Term | Cultivar | Marketable yield [kg·m$^{-2}$] Combination: Control | Goëmar Goteo | Aminoplant | Goëmar Goteo + Aminoplant | Mean for cultivar | Mean weight of rosette [kg] Combination: Control | Goëmar Goteo | Aminoplant | Goëmar Goteo + Aminoplant | Mean for cultivar |
|---|---|---|---|---|---|---|---|---|---|---|---|
| I | Excel | 7.41 a | 8.91 a | 9.21 a | 9.34 a | | 1.14 a | 1.27 a | 1.30 a | 1.40 a | |
| | Cigal | 7.50 a | 8.62 a | 7.71 a | 7.68 a | | 1.10 a | 1.25 a | 1.11 a | 1.16 a | |
| Mean for term | | 8.30 a | | | | | 1.21 a | | | | |
| II | Excel | 4.92 a | 4.28 a | 4.48 a | 4.49 a | | 0.64 a | 0.59 a | 0.60 a | 0.59 a | |
| | Cigal | 3.39 a | 3.27 a | 3.66 a | 3.34 a | | 0.47 a | 0.47 a | 0.50 a | 0.50 a | |
| Mean for term | | 3.98 b | | | | | 0.55 b | | | | |
| III | Excel | 3.70 a | 3.99 a | 3.92 a | 4.23 a | 5.74 a | 0.55 a | 0.57 a | 0.54 a | 0.57 a | 0.81 a |
| | Cigal | 3.28 a | 2.99 a | 2.79 a | 3.09 a | 4.78 b | 0.44 a | 0.48 a | 0.38 a | 0.45 a | 0.69 a |
| Mean for term | | 3.50 b | | | | | 0.50 b | | | | |
| Mean for combination | | 5.03 a | 5.34 a | 5.30 a | 5.36 a | | 0.72 a | 0.77 a | 0.74 a | 0.78 a | |

**Values in columns and rows marked with the same letters do not differ significantly at a=0.05, Tukey's HSD test**

**Table 2. Dry weight and nitrate content in the leaves of endive (mean 2008-2009)**

| Term | Cultivar | Dry weight [%] Combination: Control | Goëmar Goteo | Aminoplant | Goëmar Goteo + Aminoplant | Mean for cultivar | $NO_3^-$ [mg·100g$^{-1}$f.w.] Combination: Control | Goëmar Goteo | Aminoplant | Goëmar Goteo + Aminoplant | Mean for cultivar |
|---|---|---|---|---|---|---|---|---|---|---|---|
| I | Excel | 5.11 a | 6.25 a | 6.01 a | 5.68 a | | 40.51 a | 36.55 a | 35.04 a | 43.42 a | |
| | Cigal | 5.21 a | 5.16 a | 5.46 a | 5.24 a | | 25.80 a | 45.06 a | 48.40 a | 34.66 a | |
| Mean for term | | 5.52 b | | | | | 38.68 ab | | | | |
| II | Excel | 5.56 a | 6.00 a | 6.24 a | 5.75 a | | 36.13 a | 56.37 a | 35.33 a | 47.33 a | |
| | Cigal | 5.43 a | 4.95 a | 4.86 a | 5.02 a | | 42.72 a | 33.35 a | 29.87 a | 39.24 a | |
| Mean for term | | 5.47 b | | | | | 40.04 a | | | | |
| III | Excel | 7.08 a | 7.14 a | 6.74 a | 7.39 a | 6.24 a | 54.01 a | 40.26 a | 35.85 a | 27.84 a | 40.72 a |
| | Cigal | 6.62 a | 5.95 a | 7.16 a | 7.07 a | 5.68 b | 25.46 a | 19.90 a | 18.06 a | 22.09 a | 32.05 b |
| Mean for term | | 6.89 a | | | | | 30.43 b | | | | |
| Mean for combination | | 5.83 a | 5.91 a | 6.08 a | 6.02 a | | 37.44 a | 38.88 a | 33.76 a | 35.77 a | |

**Values in columns and rows marked with the same letters do not differ significantly at a=0.05, Tukey's HSD test**

**Table 3. Calcium and potassium content in the leaves of endive (mean 2008-2009)**

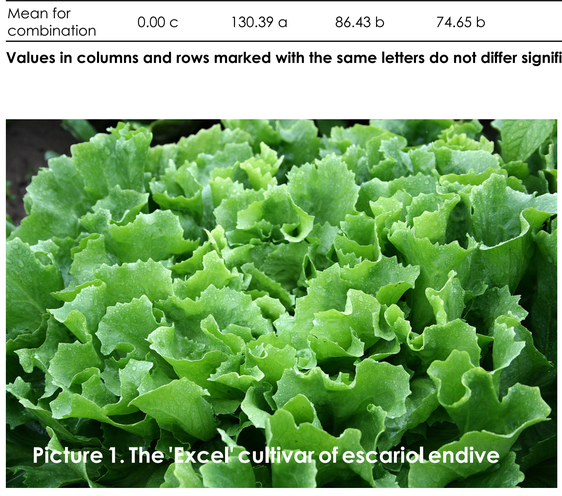
| Term | Cultivar | Ca [mg·100g$^{-1}$f.w.] Combination: Control | Goëmar Goteo | Aminoplant | Goëmar Goteo + Aminoplant | Mean for cultivar | K [mg·100g$^{-1}$f.w.] Combination: Control | Goëmar Goteo | Aminoplant | Goëmar Goteo + Aminoplant | Mean for cultivar |
|---|---|---|---|---|---|---|---|---|---|---|---|
| I | Excel | 24.98 a | 25.16 a | 21.62 a | 24.65 a | | 255.22 a | 234.60 a | 226.00 a | 232.86 a | |
| | Cigal | 19.12 a | 26.02 a | 22.77 a | 24.35 a | | 197.81 a | 209.98 a | 200.33 a | 201.56 a | |
| Mean for term | | 23.58 b | | | | | 219.79 a | | | | |
| II | Excel | 18.18 a | 29.59 a | 17.07 a | 25.34 a | | 221.06 a | 238.81 a | 213.86 a | 210.35 a | |
| | Cigal | 25.03 a | 26.53 a | 22.52 a | 16.56 a | | 223.38 a | 215.28 a | 235.09 a | 203.12 a | |
| Mean for term | | 22.60 b | | | | | 220.12 a | | | | |
| III | Excel | 29.50 a | 26.47 a | 30.64 a | 27.76 a | 25.08 a | 242.69 a | 203.69 a | 215.37 a | 213.03 a | 225.63 a |
| | Cigal | 25.30 a | 31.31 a | 23.35 a | 27.75 a | 24.22 a | 177.08 a | 188.10 a | 167.26 a | 185.20 a | 200.35 b |
| Mean for term | | 27.76 a | | | | | 199.05 b | | | | |
| Mean for combination | | 23.68 a | 33.03 a | 23.00 a | 24.40 a | | 219.54 a | 243.58 a | 209.65 a | 207.69 a | |

**Values in columns and rows marked with the same letters do not differ significantly at a=0.05, Tukey's HSD test**

**Table 4. Rutoside and kaempferol-3-o-glucoside (astragalin) content in leaves of endive (mean 2008-2009)**

| Cultivar | Rutoside [mg·100g$^{-1}$ d.w.] Combination: Control | Goëmar Goteo | Aminoplant | Goëmar Goteo + Aminoplant | Mean for cultivar | Kaempferol-3-O-glucoside (astragalin) [mg·100g$^{-1}$ d.w.] Combination: Control | Goëmar Goteo | Aminoplant | Goëmar Goteo + Aminoplant | Mean for cultivar |
|---|---|---|---|---|---|---|---|---|---|---|
| Excel | 0.00 d | 125.89 a | 92.93 b | 61.91 c | 70.18 a | 113.56 a | 418.77 a | 194.39 a | 141.33 a | 217.01 a |
| Cigal | 0.00 d | 134.90 a | 79.93 bc | 87.39 bc | 75.55 a | 101.64 a | 279.36 a | 167.18 a | 148.86 a | 174.26 a |
| Mean for combination | 0.00 c | 130.39 a | 86.43 b | 74.65 b | | 107.60 b | 349.06 a | 180.79 b | 145.09 b | |

**Values in columns and rows marked with the same letters do not differ significantly at a=0.05, Tukey's HSD test**



Picture 1. The 'Excel' cultivar of escarioLendive

Picture 2. The 'Cigal' cultivar of crispum endive

## CONCLUSIONS

1. The cultivars of endive adapted to the all-year cultivation produce varied yields depending on the term of cultivation. A higher yield of endive was obtained for the spring term cultivation.
2. The lowest content of nitrates is characteristic for the leaves of endive cultivated in the autumn. Less nitrates is noted in the cultivar of endive with crisp leaves ('Cigal').
3. Mineral-organic fertilizers affected the content of biologically active compounds causing the synthesis of rutoside and the increase of the astragalin content.