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# THE CONTENT OF MICROELEMENTS IN BLOOM OF BROCCOFLOWER AFTER FOLIAR FERTILIZATION

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***Abstract***

*World market of vegetables is becoming less conservative and has been opening itself to new cuisines, as well as to new products. Broccoflower, high quality, nice looking plant crossbred from broccoli and cauliflower, has been making a slow but steady breakthrough to the market. Meanwhile, fast life accompanied by fast food had led to epidemic of nutritional disorders. Lack of iron, zinc and manganese are amongst them. That, alongside other reasons had induced the field experiment with broccoflower, aiming to determine the effect of foliar fertilization on the content of microelements iron, manganese and zinc in the bloom of broccoflower. The experiment was set according to the method of random bloc design with three repetitions and four foliar treatments (control, zinc (0.125 g 0.1 $L^{-1}$),drin (0.1 mL 0.1 $L^{-1}$) and boron (0.175 g 0.1 $L^{-1}$)). The highest determined results show 0.87 mg of iron, 0.61 mg of zinc and 0.27 mg of manganese in 100 g of fresh matter broccoflower bloom without statistically significant differences between treatments. Those results show just how well stocked broccoflower is with these minerals, which should be useful in this plant's breakthrough on domestic vegetable market, which is still quite conservative.*

***Key words***: *broccoflower, iron, manganese, micronutrients, zinc.*

## INTRODUCTION

A hybrid of broccoli (*Brassica oleracea* var. *italica*; broccoli) and cauliflower (*B. oleracea* var. *botrytis*; cauliflower) was bred in Dutch laboratories in the 1980s and named broccoflower in 1989. The goal of growing this plant is to produce an inflorescence that develops on a shortened stem, as in cauliflower, but the flower buds within the Shannon inflorescence are more pronounced in size. In broccoli, the bloom and apical portion of the bloom stem are used, as well as the lateral bloom that develop from the leaf axils after the apical bloom is harvested. In broccoflowerand cauliflower, top dominance is not pronounced and no side shoots with bloom are formed (Fabek, 2010).

As with other cabbage varieties, the optimum temperatures for vegetative growth of Shannon are 15 to 20°C. A combination of different climatic conditions and thus the growing area, appropriate choice of varieties and growing dates can ensure a continuous supply of broccoflower. Planting should be done in moisture-saturated soil (Lešić et al., 2002).

According to research by Csizinszky (1995), the determined minerals inbroccoflower was about 480 g P $kg^{-1}$ DM (dry matter), 400 g Ca $kg^{-1}$ DM, 180 g Mg $kg^{-1}$ DM, and 550 g S $kg^{-1}$ DM. For micronutrients, the copper content in all applied nitrogen treatments, which were 98, 196 and 294 kg N $ha^{-1}$, was determined about 12 mg Cu $kg^{-1}$ DM, 22 mg Fe $kg^{-1}$ DM and 41 mg Zn $kg^{-1}$ DM For boron, with an increase in the amount of nitrogen consumed from 98 kg N to 294 kg N $ha^{-1}$, an increase in concentration from 29 to 39 mg B $kg^{-1}$ DM was observed, while the manganese content increased from 35 to 43 mg Mn $kg^{-1}$ DM.

The availability of iron depends primarily on the characteristics of the soil, especially the predominant clay minerals, the chemical and organic composition, and the pH reaction of the soil (Vukadinović and Vukadinović, 2011). Easily soluble Fe oxides are formed on very aerial soils, which have a slightly acidic to neutral pH, and this also complicates plant nutrition. Iron deficiency often occurs on alkaline soils that contain a lot of lime, especially if they are poor in organic matter. In addition to soil pH, the availability of iron is also influenced by the presence of antagonistic elements such as Mn, Cu, Zn, Ni, Co, Cr, which cause Fe chlorosis (Bergmann, 1992).

In plant tissue, about 80% of the iron is in the chloroplast stroma. Iron is involved in the structure of two types of proteins, the heme proteins and the Fe-S proteins. The heme protein group includes cytochromes, peroxidases, catalases, and leghemoglobin; the Fe-S protein group includes feredoxin, which is important in oxidation-reduction processes, especially FS I (Kirkby and Mengel, 2001).

The manganese content in plants depends strongly on the plant species, but also on the plant part or organ. Manganese plays an extremely important role in oxido-reduction processes. It is a component of a number of enzymes and activator of enolases, carboxylases, superoxide dismutases and other enzymes, but it is not a building block because it is only a component of manganese protein. It is also important for the reduction of nitrates, so in the absence of manganese, nitrates accumulate because they are reduced slowly. Good manganese availability reduces the need for N, P, K, and Ca without reducing yields, so manganese is important for more economical use of other nutrients in the soil (Vukadinović and Vukadinović, 2011).

The physiological role of Zn is very extensive and significant, especially in protein metabolism. It is an integral component of many enzymes, where it forms tetrahedral chelates as a divalent cation, i.e., binds the enzyme to the substrate. It is involved in the structure of the enzymes: carbonic anhydrase, dehydrogenase (malate, glutamate, etc.), alcohol dehydrogenase, superoxide dismutase, etc., and is also their activator. The importance of Zn is extremely important in the biosynthesis of DNA and RNA (RNA polymerase), protein synthesis (through RNA transport and influence on ribosome structure), auxin synthesis, i.e. it influences plant growth (through the influence on tryptophan synthesis) and stabilization of biomembranes. Zinc is transferred from roots to shoots through the xylem tissue. However, high concentrations of zinc have also been detected in the phloem, suggesting that zinc flows through both conducting tissues. Nitrogen-deficient plants do not show zinc retranslocation from older leaves, suggesting that zinc deficiency symptoms are more pronounced in nitrogen-deficient plants (Marschner, 1995).

To gain insight into the significance of the results obtained, we decided to compare the contents of the three microelements studied with the contents of the same microelements in broccoli and cauliflower. According to Parađiković (2011), the contents of dry matter varies in both crops. In broccoli, the range is larger and ranges from 9 to 13%, while cauliflower varies less with 11 to 13%.

According to USDA (2013), broccoli contains 0.52 mg Fe 100 $g^{-1}$FM (fresh matter), 0.35 mg Zn 100 $g^{-1}$FM, and 0.151 mg Mn 100 $g^{-1}$FM. Cauliflower contains 0.2 mg Fe 100 $g^{-1}$FM, 0.11 mg Zn 100 $g^{-1}$FM, and 0.082 mg Mn 100 $g^{-1}$FM.

The objective of this study was to determine the effect of foliar fertilization on the content of the microelements iron, manganese, and zinc in broccoflower bloom.

## MATERIALS AND METHODS

For this study, a field fertilization trial with broccoflower (Amfora variety, Bejo company) was conducted in 2009 at the Maksimir Experimental Station of the Department of Vegetable Crops of the Faculty of Agriculture in Zagreb. The trial was carried out according to the complete randomized block design in three replicates and with four foliar treatments: Control (water application), Zinc (0.125 g 0.1 $L^{-1}$), Drin-organic liquid biostimulant (0.1 mL 0.1 $L^{-1}$), Boron (0.175 g 0.1 $L^{-1}$). Foliar treatmentswere applied twice: 1st Oct 2009 and 14th Oct 2009. Sowing was performed on 30th June 2009 and planting in the field on 31st July 2009 on the soil mulched with foil. The row spacing was 0.5 m and in the row 0.4 m, which corresponds to 5 plants per 1 $m^2$. The basic experimental plot consisted of two rows with 7 plants per row (14 plants per 1 plot). The harvest was carried out once.

The standard agricultural measures were used. Soil fertilization was applied before foil spreading on the soil surface based on the planned yield of 30 t $ha^{-1}$ (667 kg NPK 7-20-30 $ha^{-1}$, 100 kg $K_2SO_4$ $ha^{-1}$, and 400 kg KAN $ha^{-1}$. Foliar fertilization with urea was also applied twice during the growing season.

During harvest, broccoflower bloom were randomly selected from each plot for the average sample for chemical analysis. Samples were dried at 105° C and then grinded and homogenized. Iron, zinc and manganese were determined after digestion with conc. $HNO_3$ and $HClO_4$ in a microwave oven by atomic absorption spectrometer (AOAC, 1995) in the laboratory of the Department of Plant Nutrition at the Faculty of Agriculture in Zagreb.

Statistical data processing was performed using the analysis of variance model (ANOVA). The SAS System for Win. ver 9.1 program (SAS Institute Inc.) was used. Tukey's test for significant thresholds (SAS, 2002-2003) was used to test the results. Data were processed using the statistical software package SAS System for Win Ver. 9.1 (SAS Institute Inc., 2002-2003).

## RESULTS AND DISCUSSIONS

Table 1 shows significant differences in the dry matter content. The lowest percentage of dry matter was determined in the control treatment (9.1%), and the highest in the treatment with zinc (10.3%). The obtained results are significantly lower than those of cauliflower (11-13%) and are at the lower range of the results that can be obtained with broccoli (9-13%) (Parađiković, 2011).

Table 1. Dry matter content in broccoflower bloom, depending on treatment

| Treatments | % dry matter (DM) |
|---|---|
| Control | 9.1 b |
| Zinc | 10.3 a |
| Drin | 9.4 ab |
| Boron | 9.7 ab |

Different letters represent significantly different values according to Tukey's test, $p \leq 0.05$. The non-letter values are not significantly different.

Iron content in dry matter showed significant variations, from 80.6 mg Fe $kg^{-1}$ DM in the zinc treatment to 95.8 mg Fe $kg^{-1}$ DM in the control treatment (Table 2). The nutrients content in 100 g of fresh matter, which is considered the norm in the diet, is usually used as a reference content when calculating the ability to meet the needs of certain minerals, vitamins, carbohydrates and other food components. The iron content in broccoflowerfresh matter ranges from 0.82 to 0.87 mg Fe 100 $g^{-1}$FM (Table 2) and no statistically significant difference was found between fertilizer treatments. These results are significantly higher than the iron content of broccoli (0.52 mg Fe 100 $g^{-1}$ FM) and cauliflower (0.2 mg Fe 100 $g^{-1}$ FM), according to USDA (2013).

Table 2. Broccoflowerbloom iron content in dry and fresh matter, depending on treatment

| Treatments | mg Fe $kg^{-1}$DM | mg Fe 100 $g^{-1}$ FM |
|---|---|---|
| Control | 95.8 a | 0.87 |
| Zinc | 90.6 c | 0.82 |
| Drin | 90.8 ab | 0.85 |
| Boron | 86.8 bc | 0.84 |

Different letters represent significantly different values according to Tukey's test, $p \leq 0.05$. The non-letter values are not significantly different.

In dry matter, again, the blooms of the control treatment are the richest with 28.5 mg Mn $kg^{-1}$DM and those of the zinc treatment the poorest with 25.9 mg Mn $kg^{-1}$DM. For fresh matter, the results are almost identical, ranging minimally from 0.26 to 0.27 mg Mn 100 $g^{-1}$FM. Compared to broccoli with 0.151 mg Mn 100 $g^{-1}$FM and cauliflower with 0.082 mg Mn 100 $g^{-1}$FM according to USDA (2013), we have once again results that prove to be significantly better (Table 3).

Table 3. Broccoflower bloom manganese content in dry and fresh matter, depending on treatment

| Treatments | mg Mn $kg^{-1}$DM | mg Mn 100 $g^{-1}$FM |
|---|---|---|
| Control | 28.5 a | 0.26 |
| Zinc | 25.9 b | 0.27 |
| Drin | 27.4 ab | 0.26 |
| Boron | 26.4 b | 0.26 |

Different letters represent significantly different values according to Tukey's test, $p \leq 0.05$. The non-letter values are not significantly different.

Similar to iron, Table 4 shows that, again, the highest content of the observed element is found in the control treatment (68.1 mg Zn $kg^{-1}$ DM) and the lowest in the zinc treatment (58.1 mg Zn $kg^{-1}$ DM). As with iron, there are no significant differences in fresh matter, and zinc content ranges from 0.58 to 0.62 mg Zn 100 $g^{-1}$ FM. Compared to broccoli (0.35 mg Zn 100 $g^{-1}$ FM, according to USDA (2013) and cauliflower (0.11 mg Zn 100 $g^{-1}$ FM, according to USDA (2013), broccoflower stands out as a much richer source of this mineral, even more so than for iron.

Tablica4. Broccoflower bloom zinc content in dry and fresh matter, depending on treatment

| Treatments | mg Zn $kg^{-1}$DM | mg Zn 100 $g^{-1}$FM |
|---|---|---|
| Control | 68.1 a | 0.62 |
| Zinc | 58.1 b | 0.59 |
| Drin | 64.2 ab | 0.60 |
| Boron | 59.9 b | 0.58 |

Different letters represent significantly different values according to Tukey's test, $p \leq 0.05$. The non-letter values are not significantly different.

Considering these results, it can be concluded that broccoflower is a very worthy agricultural culture. The first reason for this, is its excellent ability to uptake nutrients, which can be concluded from the very small variations in the results obtained in different treatments. One season may not be a reliable indicator, but the results obtained showed the cost-effectiveness of foliar fertilization in this crop under the given conditions, as the control treatment did not lag behind the others.

Regardless of the different treatments, the recorded contents of all nutrients showed that broccoflowercan be a significant source of these nutrients in the diet. Since these are nutrients, that a large part of today's population is deficient in, these results can be considered as an additional reason to increase the acreage of this crop and, consequently, the market for the studied product. The quality of the product was very high compared to its main competitors in terms of the parameters observed.

## CONCLUSIONS

The obtained results showed the exceptional ability of broccoflower to accumulate micronutrients such as iron, manganese and zinc regardless the treatment. In 100 g of fresh broccoflower bloom, the highest levels of 0.87 mg Fe, 0.62 mg Zn, and 0.27 mg Mn were obtained, without statistically significant variations between treatments.

In addition to the other benefits, broccoflower offers the consumer, as well as the possibility of long-term storage with minimal loss of weight and quality, and there is little to counterbalance the reasons for growing this crop. So, it should suggest to increase acreage and market share so that the only real obstacle, the high price, can be removed. The data obtained gain particular significance in comparison with cauliflower and broccoli, the competitors, but also the "parents" of the observed crop.

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