EVALUATION OF LUTEIN AND ZEAXANTHIN CONTENT IN SWEET CORN FROM THE BLACK CRIȘUL MEADOW

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RESEARCH ARTICLE

Abstract

This study explores the influence of different fertilization regimes on the lutein and zeaxanthin content in sweet corn cultivated in the Black Crișul Meadow. Four experimental variants are analyzed, including a plot without fertilization, one with organic fertilization (compost), a third with complex NPK fertilizer, and a fourth with NPK plus microelements. The determination of carotenoids is performed by high-performance liquid chromatography (HPLC). The results provide valuable insights into the impact of fertilization on the nutritional quality of sweet corn, highlighting the potential of organic fertilization to enhance the content of bioactive compounds.

Keywords: lutein, zeaxanthin, sweet corn, carotenoids, fertilization

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INTRODUCTION

Sweet corn (Zea mays saccharata) is a crop of significant economic importance, valued for its high sugar content and versatility in food applications. Beyond its pleasant taste, this type of corn is recognized for its nutritional contribution, especially through its carotenoid content. Lutein and zeaxanthin, two of the most important carotenoids present in sweet corn, are known for their essential role in eye health, as they protect the retina from the harmful effects of blue light and reduce the risk of age-related macular degeneration (AMD). Given the growing demand for functional foods rich in health-promoting compounds, studying the variability in lutein and zeaxanthin content under different fertilization conditions in corn has become of great interest.

Environmental factors and the type of fertilization applied significantly influence plant development and the accumulation of bioactive substances in plants. Fertilization, in particular, plays a crucial role in optimizing plant growth and nutrient content. In this context, using different types of fertilizers—organic and inorganic—can impact the carotenoid composition in sweet corn. Organic fertilization, such as compost, improves soil structure and ensures a balanced nutrient supply, while inorganic fertilizers, like NPK (nitrogen, phosphorus, potassium), provide a quick and direct source of essential elements for plant growth. Additionally, the addition of microelements can further stimulate metabolic processes, enhancing the synthesis of compounds of interest, such as carotenoids.

MATERIAL AND METHOD

In this study, the content of lutein and zeaxanthin was determined in sweet corn cultivated in four plots with different fertilization treatments, located in the Black Crișul Meadow (Căpâlna village), an agricultural area favorable for corn cultivation due to its soil and local climate conditions. The research was conducted using the Latin rectangle method, an experimental approach that effectively controls unwanted variations, ensuring statistically significant results. The four fertilization treatments included: an unfertilized plot (control), a plot fertilized organically with compost, a plot fertilized inorganically with complex NPK fertilizer, and a plot fertilized with NPK fertilizer and microelements. The main objective of this study is to determine how different fertilization treatments influence the lutein and zeaxanthin content in sweet corn, thus contributing to the optimization of agricultural practices for enhancing the nutritional value of sweet corn crops.

The research was conducted in the Black Crișul Meadow (Căpâlna village, in 2024), an agricultural region well-known for its fertile soils and climate conditions favorable to corn crops.

The figure 1.1 shows a satellite image of the area where the research was conducted.

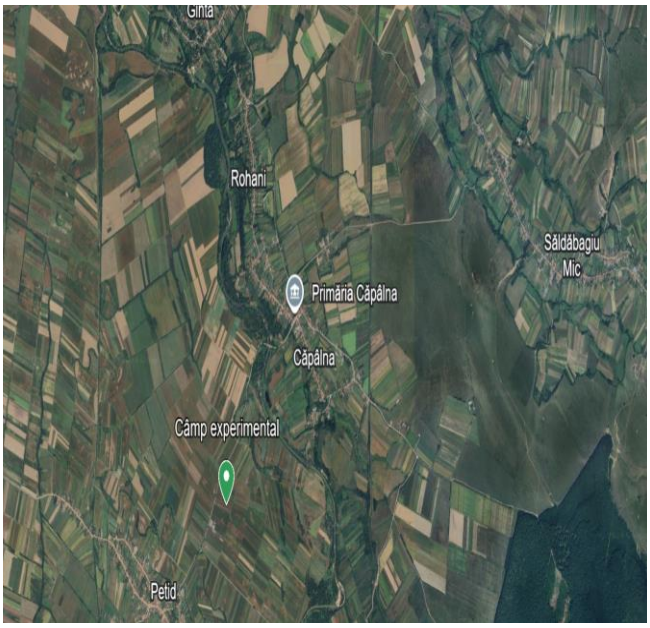

Figure 1.1 **The experimental Field**

The soil in this area is predominantly loamy-clay, with good water retention capacity and a structure that supports optimal crop growth. The soil type on which the experiments were conducted is a Gleyic Alluvial Soil, typical of alluvial zones, formed through successive sediment deposits brought by flowing waters (Brejea R. 2010). This soil type is commonly found in river valleys and has high fertility due to its rich organic matter and mineral content. Gleyic Alluvial Soil is characterized by a loamy or loamy-clay texture that ensures good water retention, favoring crops requiring constant moisture(Brejea R. 2011).

Sweet corn (Zea mays saccharata) grows well in this type of soil due to its balanced combination of drainage and water retention. In this soil, corn can easily access nutrients such as nitrogen, phosphorus, and potassium, which contribute to vigorous growth and the development of healthy, sugar-rich, carotenoid-rich ears.

Figure 1.2 illustrates the Gleyic Alluvial Soil in the Black Crișul Meadow.

Figure 1.2 **The gleic alluvium from Black Crisului Meadow(Căpâlna)**

The research was conducted using the Latin rectangle method, an effective approach for controlling the effects of uncontrolled variability and minimizing experimental errors (Brejea R et al, 2022). Four land plots were used, each measuring 5 meters in width and 20 meters in length. The plots were arranged to allow for the uniform distribution of fertilization regimes and to reduce the effects of microclimatic or soil fertility variations between plots.

Each plot received a different fertilization treatment:

Plot 1, Control: No fertilizer applied.

Plot 2, Organic Fertilization: Compost applied as a source of natural nutrients.

Plot 3, Inorganic Fertilization: Application of complex NPK fertilizer (20-20-20), containing nitrogen (N), phosphorus (P), and potassium (K) in equal proportions.

Plot 4, NPK and Micronutrient Fertilization: Application of complex NPK fertilizer (20-20-20) enriched with micronutrients (iron, zinc, manganese, copper, molybdenum).

Figure 1.3 illustrates the four fertilization variants.

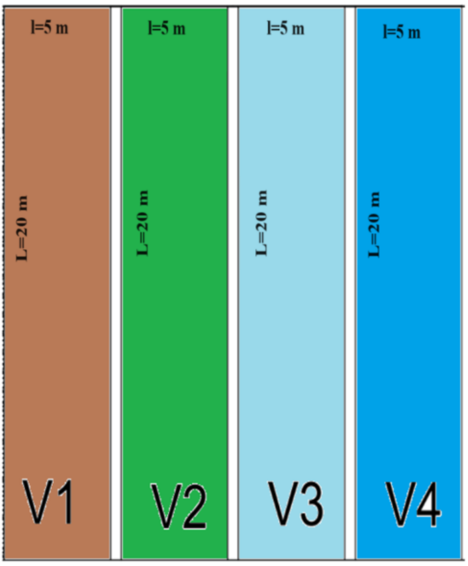

Figure 1.3 **Fertilization variants**

The harvesting of sweet corn was conducted at the full maturity stage of the plants when the kernels had reached optimal development and maximum carotenoid concentration. Ten representative ears were collected from each plot, and the kernels were manually extracted.

Laboratory analysis was performed at the University of Debrecen, where the lutein and zeaxanthin content from each plot's sweet corn was measured. Lutein and zeaxanthin are two of the main carotenoids present in sweet corn, both possessing significant antioxidant properties. These carotenoids are well-known for their essential role in eye health, particularly in protecting the retina from blue light and reducing the risk of age-related macular degeneration (AMD). This research aimed to determine lutein and zeaxanthin concentrations in sweet corn kernels based on the different fertilization treatments applied.

Lutein is a hydrophobic yellow carotenoid found in significant amounts in sweet corn kernels (Perry, A et al, 2009). In the human body, it concentrates in the macula of the eye, playing a crucial role in filtering harmful blue light. In this study, corn samples were analyzed to determine lutein concentration using high-performance liquid chromatography (HPLC).

Zeaxanthin is another important carotenoid found in sweet corn kernels, contributing alongside lutein to the intense yellow coloration of the kernels. It plays a vital role in eye protection against oxidative stress, with remarkable antioxidant properties (Song, J et al, 2016). Like lutein, zeaxanthin in the corn samples was analyzed using the HPLC method.

After carotenoid extraction with acetone, samples were injected into the same chromatographic system.

High-performance liquid chromatography (HPLC) is an analytical technique that enables the separation and quantitative determination of chemical compounds within a sample(De Oliveira et al, 2007) . HPLC was chosen for determining the lutein and zeaxanthin content in sweet corn kernels due to its high sensitivity and specificity, making it suitable for carotenoid analysis, given these compounds are present in low concentrations in the plant matrix(Calvo-Brenes et al, 2019).

The analysis was based on the study by Murillo, E., Meléndez-Martínez, A. J., and Portugal, F. (2010), which screened vegetables and fruits in Panama as rich sources of lutein and zeaxanthin. The HPLC analyses were conducted using the HITACHI Elite LaChrom HPLC (Merck, Darmstadt, Germany), equipped with a quaternary pump, an automatic injector, and a diode-array detector. Chromatograms were recorded using EZChrom Elite software, Version 3.3.2 (Agilent Technologies).

Analytical standards for lutein (HPLC-grade; 94110 Supelco) and zeaxanthin (14681 Supelco), as well as certified reference material for lutein (PHR1699; Supelco), were also used. Lutein and zeaxanthin quantification in samples was performed through external calibration, with dose-response curves obtained from the standards.

Figure 1.4 depicts the equipment used to determine the lutein and zeaxanthin content.

Figure 1.4 **Equipment to detect the carotenoid content of sweet corn**

This hybrid is noted for its high sugar and carotenoid content, particularly lutein and zeaxanthin, making it suitable for studies focused on bioactive compounds in corn. DessertR78 is adapted to a wide range of soil and climate conditions, with a strong ability to grow in both fertile soils and those with moderate drainage, such as those in the Black Crișul Meadow.

The sweet corn was harvested at full plant maturity when the kernels reached their optimal development stage and maximum carotenoid concentration. Ten representative ears were collected from each plot, and the kernels were manually extracted.

Figure 1.5 shows the DessertR78 hybrid.

Figure 1.5 **DessertR78 hybrid**

The area of Black Crisului Meadow is characterized by a moderate temperate-continental climate, with seasonal variations in temperature and precipitation, which directly influences the development of agricultural crops.

During the monitored period, temperatures followed an upward trend from the beginning of the year until mid-summer, favoring the germination and growth of sweet corn. Monthly average temperatures started at 2.2°C in January and reached up to 25.8°C in July, providing an optimal growing season for this crop. The high temperatures in May, June, and July, with values of 18.0°C, 22.6°C, and 25.8°C, respectively, created favorable conditions for the development of sweet corn, contributing to a healthy yield. Figure 1.6 represents the evolution of the average monthly temperature in the studied area.

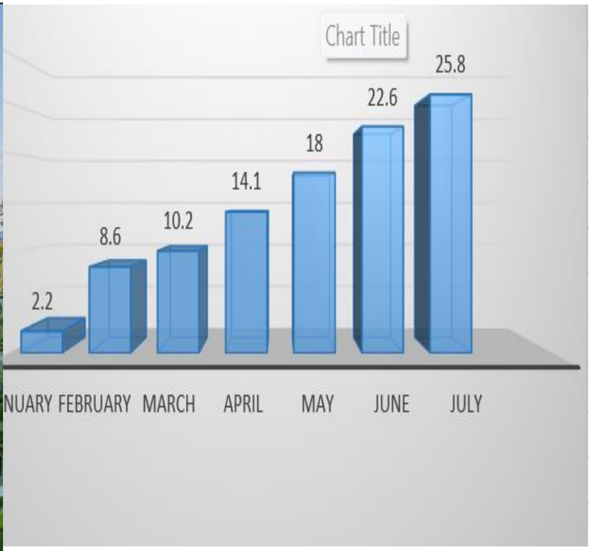

Figure 1.6 **Evolution of the average monthly temperature in the studied area**

The amount of precipitation varied significantly between months, directly influencing soil water availability. The highest rainfall was recorded in the months of April (41.39 l/m2) and June (75.93 l/m2), essential periods for the development of corn, as it provides the necessary moisture for germination and early plant growth. The low rainfall in July (17.84 l/sq m) and May (16.85 l/sq m) suggests a drought trend in the summer period.

Figure 1.7 illustrates a diagram of the amount of monthly precipitation in the studied area

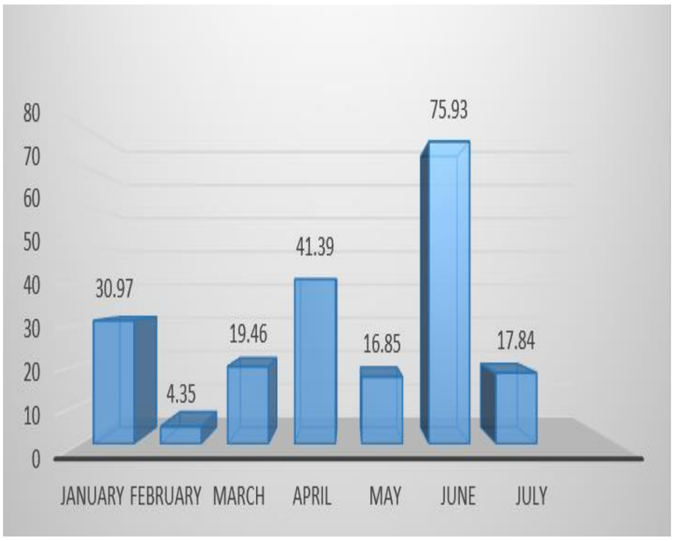

Figure 1.7 **Amount of monthly precipitation in the studied area**

For the statistical analysis of the data, descriptive indicators (mean, standard deviation) were calculated for each fertilization variant. Subsequently, analysis of variance (ANOVA) was used to identify significant differences between the experimental variants regarding lutein and zeaxanthin content. If ANOVA indicated significant differences, a post hoc test was applied to determine which pairs of variants had significant differences.

RESULTS AND DISCUSSIOS

To evaluate the impact of different fertilization treatments on lutein and zeaxanthin content in sweet corn, quantitative analyzes were performed using HPLC. The results obtained, expressed in mg/g of dry matter, are presented in Table 1.

The results presented in Table 1 suggest that the compost treatment (V2) had the greatest impact on the concentrations of lutein and zeaxanthin, compared to the control variant (V1) and the treatments based on chemical fertilization (V3 and V4).

To verify if the differences observed between fertilization variants are statistically significant, analysis of variance (ANOVA) was applied. The ANOVA results showed that the fertilization regime has a significant effect on the concentrations of lutein ($p < 0.05$) and zeaxanthin ($p < 0.05$). Post-hoc analyses (e.g., Tukey test) confirmed that the compost-fertilized variant (V2) had significantly higher values compared to the control variant (V1) and the NPK-fertilized variants (V3 and V4).

This effect can be explained by the gradual release of nutrients from the compost, which promotes more efficient absorption of the nutrients required for carotenoid synthesis.

Table 1

The content of lutein and zeaxanthin in Black Crișul Meadow (Căpâlna, 2024)

Variants	Fertilization	Lutein content mg/g dry substance (Mean ± SD)	Zeaxanthin content mg/g dry substance (Mean ± SD)
V1	Without fertilization	0.44 ± 0.02	0.23 ± 0.01
V2	Fertilization with compost	0.60 ± 0.03	0.36 ± 0.02
V3	Fertilizing with NPK complex compound	0.50 ± 0.02	0.29 ± 0.01
V4	Fertilizing with complex NPK + microelements	0.52 ± 0.01	0.30 ± 0.01

Although NPK fertilization is important for overall plant growth, it did not have the same effect on carotenoid accumulation, likely due to the rapid release of nutrients, which does not perfectly match the plants' physiological needs for lutein and zeaxanthin synthesis.

In the case of variant V4 (NPK + microelements), the statistical analysis revealed a slight increase in lutein and zeaxanthin concentrations compared to the simple NPK variant (V3), but the differences were not statistically significant. This suggests that, although microelements contribute to enzymatic processes that influence plant metabolism, their effect on carotenoid synthesis is not as pronounced as with organic fertilization.

CONCLUSIONS

The results of this study indicate that the fertilization regime significantly influences the concentrations of lutein and zeaxanthin, with compost fertilization (V2) showing the most pronounced positive effect compared to the control (V1) and NPK-based fertilization treatments (V3 and V4). The gradual nutrient release from compost likely contributes to a more efficient nutrient absorption, supporting the synthesis of carotenoids. On the other hand, although NPK fertilization is important for general plant growth, it does not appear to enhance carotenoid accumulation to the same extent, likely due to the rapid nutrient release that does not align as well with the plants' physiological needs for lutein and zeaxanthin synthesis.

In the case of variant V4 (NPK + microelements), while there was a slight increase in the concentrations of lutein and zeaxanthin compared to the simple NPK treatment (V3), the differences were not statistically significant. This suggests that, although microelements play a role in enzymatic processes influencing plant metabolism, their effect on carotenoid synthesis is less pronounced than that of organic fertilization.

These findings underline the importance of considering both nutrient release dynamics and fertilization type when aiming to enhance carotenoid content in plants, particularly when seeking sustainable and efficient fertilization practices.

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