Scientific Papers. Series A. Agronomy, Vol. LXV, No. 1, 2022
ISSN 2285-5785; ISSN CD-ROM 2285-5793; ISSN Online 2285-5807; ISSN-L 2285-5785

EFFECT OF FOLIAR FERTILIZATION ON THE QUALITY PARAMETERS OF WHEAT AND MAIZE CROPS

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Abstract

Wheat (Triticum aestivum L.) and maize (Zea mays L.) are widely consumed cereal crops throughout the world, representing a major staple food. Increased demand of food requires higher crop yields which are dependent of climatic conditions and soil fertility. Hence, for achieving this objective, it is necessary to adopt proper fertilization schemes. The excessive use of chemical fertilizers in agricultural systems poses negative environmental effects and accordingly, use of ecological inputs became a safer alternative. In this context, the aim of the present study was to assess the effect of ecological inputs' application on quality indicators for wheat and maize crops. In the experimental scheme was included foliar fertilization during vegetation period with CODAMIX and ECOAMINOALGA, as one treatment for wheat and two treatments for maize. The obtained results indicated that both applied fertilizers favoured accumulation of protein and starch in cereal seeds at levels higher than those identified for control variant. On the basis of the achieved data, it was found that application of ECOAMINOALGA was more efficient than CODAMIX and stimulated formation of seeds with better quality parameters for both crops subjected to this study.

***Key words**: foliar application, maize, proteins, starch, wheat.*

INTRODUCTION

Modern agriculture is mainly focused on using the resources with maximum efficiency to ensure a greater productivity for feeding the growing global population. Wheat (*Triticum aestivum* L.) and maize (*Zea mays* L.) are some of the most important cereal crops used in human food and animal feed throughout the world. Therefore, increasing cereals yield and crop quality has become an essential target.

To achieve this goal regardless of climatic conditions and soil properties, it is necessary to adopt proper fertilization schemes, avoiding an excessive use of chemical fertilizers which cause soil degradation and negative environmental effects.

Currently, researchers are more interested in using organic fertilizers and plant biostimulants which are considered a sustainable approach to improve the growth and productivity of field crops. By definition, biostimulants are substances that have ability to enhance plant growth, nutrient efficiency, abiotic stress tolerance in plants and crop quality traits (Van Oosten et al., 2017). Biostimulants are available in a variety of formulations with different ingredients in composition as humic substances, seaweed extracts (supplying active plant growth substances such as auxins and cytokinins) and amino acids (Kauffman et al., 2007).

Amino acids are the basic building blocks of proteins and perform numerous functions: growth stimulating, precursors of auxin and chlorophyll, stimulation of seeds germination (Paleckiene et al., 2007). Although plants are able to synthesize amino acids, this process consumes a lot of energy and consequently, the application of ready for uptake amino acids allows plants to save energy and to intensify their development, especially under critical conditions (Maini, 2006; Popko et al., 2014).

On the other hand, the cultivation of high quality cereal crops needs an adequate supply of micronutrients, which act as stimulants for macronutrients, in particular nitrogen (Potarzycki, 2004). Nevertheless, the availability of micronutrients is limited by the characteristics of the soil, as well as the agricultural practices, therefore an additional supply for plants is required.

The new stimulant products allow achieving significant increases in the quality and quantity of yield by improving the efficiency of fertilizer nutrients uptake. In fertilizers, amino acids form organic connections with minerals (amino acid chelates), which increase the availability of nutrients for plants (Popko et al., 2018; Niewiadomska et al., 2020).

Lately foliar application of micronutrients seems to be effective and it is becoming more popular (Johansson, 2008; Popko et al., 2018). Thus, recent studies reported that foliar application of liquid seaweed extract (Makawita et al., 2021) and organic fertilizers (Hussain et al., 2022) was efficient regarding nutrient availability for optimum development and growth resulting in improving quality of field crops cultivated under unfavourable environments.

Also, a positive impact of biostimulants (seaweed extracts and free amino acids complex) on the bean seeds antioxidant potential was noted, expressed by the increased synthesis of phenolics, flavonoid, anthocyanins and antioxidant activities (Kocira et al., 2020). Evaluation of the biostimulant potential for an aqueous extract obtained from duckweed (*Lemna minor* L.) on maize has evidenced improved maize germination, biomass, leaf area, pigment content (Del Buono et al., 2021).

Most studies revealed a positive impact of foliar fertilization not only on cereals crops but also on vegetable production. Application of organic products containing free amino acids, polysaccharides and oligoelements induced obtaining of pepper (Balan et al., 2014), tomatoes (Dobrin et al., 2018) and eggplant seedlings (Dobrin et al., 2016) with high quality and strong roots.

However, some authors reported no differences on yield when foliar treatments with comercial biostimulants were used on corn and soybean (Sharma et al., 2018; Lilley, 2020). Also, Feitosa de Vasconcelos (2019) noted small or no significant increase in the content of the nutrients in the maize and soybean.

In this context, the aim of the present study was to evaluate the influence of some ecological inputs' application on quality indicators for wheat and maize crops.

In the experimental scheme was included foliar fertilization during vegetation period with the organic fertilizers CODAMIX and ECOAMINOALGA as one treatment for wheat and two treatments for maize. These ecological products can supply cultivated plants with amino acids and elements in the case of their critical deficiencies. As amino acids are known to facilitate the transport of elements (metal translocation through xylem) (Jan et al., 2016), it is expected that an improvement of the quality of cereal grains to occur under this treatment.

MATERIALS AND METHODS

This study reports the results of the researches performed on wheat and maize seeds in order to evaluate the accumulation of protein and starch under foliar fertilization with two products destined to organic agriculture which act as biostimulant for plant growth and micronutrient fertilizer.

The field experiment was conducted in 2020 at the Agricultural Research and Development Station Pitești, Romania, and it was used as test crops wheat (Trivale variety) and maize (F376 hybrid).

The experimental scheme for each crop was composed of three variants: V1 - Control variant (no fertilization); V2 - Foliar fertilization with CODAMIX; V3 - Foliar fertilization with ECOAMINOALGA.

CODAMIX is a water-soluble fertilizer which contains microelements (Fe, Mn, Zn, Cu, B, Mo) chelated by citric acid, lignosulphonic acids and EDTA. It is used often as a supplement to NPK fertilising schedules (Sustainable Agro Solutions, Codamix producer, 2021).

ECOAMINOALGA is defined by its producer as a biostimulant obtained from soy and seaweed protein hydrolysis with over 40% organic matter and amino acids content. It is recommended for use in organic farming.

In Table 1 are centralized treatments for each experimental crop.

Table 1. Fertilization scheme

Experimental crop	Wheat	Maize
Preceding crop	Sunflower	Maize
Basal application	Bio Enne* 250 kg/ha	Bio Enne* 250 kg/ha
First treatment application (phenophase)#	25.05.2020 (grain filling)	25.05.2020 (7-8 leaves)
Second treatment application (phenophase) #	-	09.06.2020 (8 leaves)

*Bio Enne contains: 12% organic nitrogen, 23% water soluble sulphuric anhydride, 35% organic carbon

#Foliar application; 2.5 L solution 0.5%/ha/treatment; applied volume 150 L.

Cereal seeds obtained after harvest were analysed for protein and starch content using appropriate biochemical methods. The seeds samples were dried to room temperature and ground with the laboratory grinder into fine powder. The extractions of the biochemical compounds were conducted according to the protocol used for each determination.

Crude protein content was determined after digestion of the vegetal material by the Kjeldahl method described by Farid et al. (2017) with some modifications: 0.5 g of air-dried seeds was digested with 10 mL of concentrated sulphuric acid in Kjeldahl flask in the presence of solid catalyst. A volume of 30 mL of 33% sodium hydroxide solution was added after digestion. The released ammonia was received into 10 mL of 3% boric acid. The resulted ammonia was titrated with 0.1 N hydrochloric acid in the presence of Groack indicator (methyl red and methylene blue). The percentage of total nitrogen was estimated and converted into crude protein content. Data are presented as the mean of three replications with standard deviation.

Starch content was determined by a polarimetric method based on the optically activity of starch (Peris-Tortajada, 2004; Fărcaş et al., 2013). As starch is a biochemical compound insoluble in water, its extraction was carried out by boiling the samples in a hydrochloric acid solution. After dissolution, the samples were filtered and the optical rotation was measured using a polarimeter. The optical activity was measured at 20ºC, in a sample cell of 100 mm optical path length. Data are presented as the mean of three replications with standard deviation.

In addition to the above mentioned analyses, moisture was determined gravimetrically by mass difference before and after heating at 105ºC. Dry weight (DW) was used in calculation of crude protein content and starch content.

Statistical analyses were performed with the one-way Analysis of Variance (ANOVA). All measurements were carried out in triplicate and the results are presented as means value ± S.D. (standard deviation). The results were expressed in g% DW. Each experimental variant was compared with the control variant and the *P* values of <0.05 were considered significant.

RESULTS AND DISCUSSIONS

The performed researches aimed to reveal the qualitative improvement of the cereal seeds under foliar fertilization applied on the wheat and maize crops.

The effect of foliar fertilization on wheat seeds

The wheat seeds from both fertilized variants showed a higher content of crude protein (Figure 1) and starch (Figure 2) compared with the control variant.

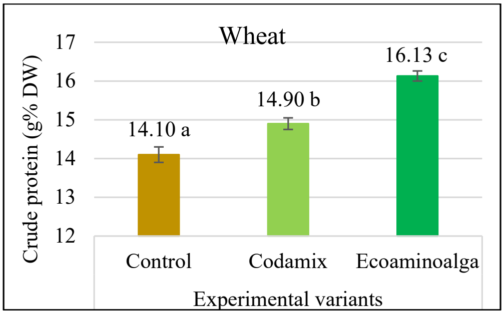

Figure 1. Accumulation of crude protein in wheat seeds
Note: all data were expressed as mean values ± S.D. (n = 3); significantly different means are indicated with different superscript letters (p<0.05)

Regarding the crude protein content, it worth to be mentioned the variant treated with ECOAMINOALGA which registered the highest value (16.13 ± 0.13 g%) as compared both to the control (14.10 g%) and the CODAMIX variant (14.90 g%) (Figure 1). In fact, statistical analysis showed significant differences between seeds protein content in all experimental variants. An increase of 5.67%,

respectively 14.39% over control variant were found in case of CODAMIX and ECOAMINOALGA fertilization. Stepien and Wojtkowiak (2016) also reported that micronutrients foliar spraying contributed to a high proportion of proteins in wheat grain due to plant metabolism stimulation, but no significant difference was observed.
Popko et al. (2018) reported for wheat grains an increase of the protein content with 2.3-3.1% as against control variant under the application of amino acids based biostimulants products.
Moreover, Pichereaux et al. (2019) investigated the impact of a marine and a fungal biostimulants applied to durum wheat leaves and found an increase in protein quantity associated with a modification of the protein composition in the grains: after biostimulants treatments fifty proteins were found to be differentially represented, all of these being involved in metabolic pathways and processes.

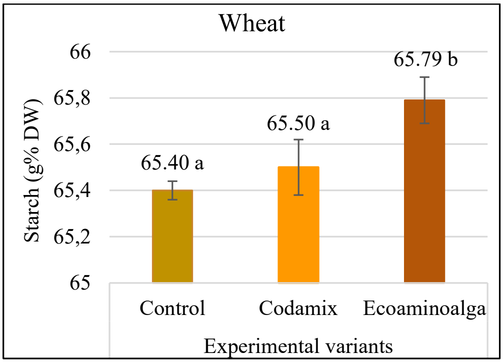

Figure 2. Accumulation of starch in wheat seeds
Note: all data were expressed as mean values ± S.D. (n = 3); significantly different means are indicated with different superscript letters (p<0.05)

Having in view that starch is the main source of energy in wheat grain, ranging from 60% to 70% of grain mass (Popko et al., 2018), we considered important to quantify the starch content.
The performed analyses evidenced higher values of starch content in wheat seeds for the variants treated with biostimulant products, as it follows: 65.50 ± 0.12 g% after the application of CODAMIX, respectively 65.79 ± 0.10 g% after the application of ECOAMINOALGA, in comparison with the control variants (65.40 ± 0.04 g%); the difference was significant only in the case of ECOAMINOALGA treatment (Figure 2).

The effect of foliar fertilization on maize seeds

Laboratory tests showed an increase of both biochemical characteristics of maize seeds: protein (Figure 3) and starch contents (Figure 4).
Significant differences were noted between all variants in terms of protein content. The achieved data regarding the crude protein content in maize seeds indicated an increase of 4.62% in the variant treated with CODAMIX and of 13.87% in the ECOAMINOALGA variant compared to the control variant (Figure 3).

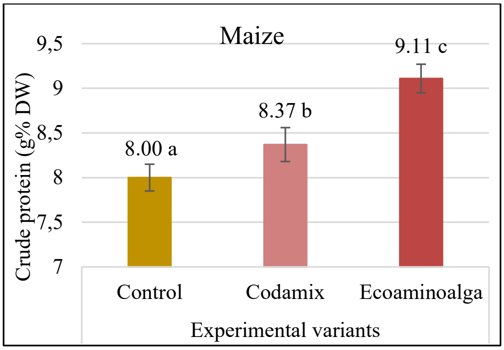

Figure 3. Accumulation of crude protein in maize seeds
Note: all data were expressed as mean values ± S.D. (n = 3); significantly different means are indicated with different superscript letters (p<0.05)

The starch content instead registered a slight increase in the fertilized variants (0.06% for CODAMIX and 0.35% for ECOAMINOALGA), significant differences in terms of recorded values being noted only for the ECOAMINOALGA variant both compared to the CODAMIX variant and to the control variant (Figure 4).

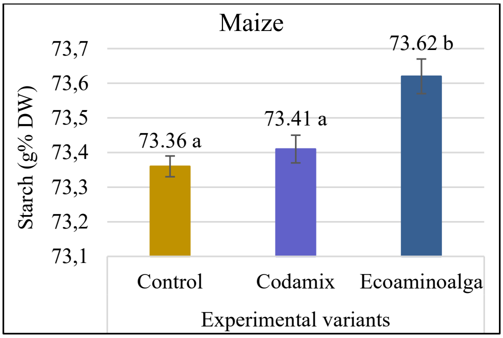

Figure 4. Accumulation of starch in maize seeds
Note: all data were expressed as mean values ± S.D. (n = 3); significantly different means are indicated with different superscript letters (p<0.05)

The effects of foliar fertilization on maize crop were studied also by other authors, but the conclusions are ambiguously. Some works reported no differences on yield when foliar micronutrients were used (Mueller & Diaz, 2011; Sharma et al., 2018). Instead, Macra and Sala (2021) found that the starch content ranged from 65.99 to 69.93 ± 0.21 g% when improved mineral fertilization with nitrogen by adding foliar biostimulator.

CONCLUSIONS

Results of the performed experiment showed beneficial effects of the foliar treatments with biostimulant products (CODAMIX and ECOAMINOALGA) on the quality parameters (protein and starch contents) for wheat and maize crops.

On the basis of the achieved data, it was found that application of ECOAMINOALGA was more efficient than CODAMIX and stimulated formation of seeds with better quality parameters for both crops subjected to this study. However, a more obvious increase in the accumulation of nutrients in the seeds after foliar treatment was noted for the wheat crop by comparison with the maize.

The biostimulant products tested in the present study are suitable to be recommended for an efficient agricultural production, mainly for organic agriculture, since they are safe for the environment and contribute to high quality crops.

ACKNOWLEDGEMENTS

This work was made with the support of Ministry of Agriculture and Rural Development, and was financed from Project ADER 1.4.4. "*Identification, evaluation, testing, development and validation of analysis methods of nutrients and contaminants from inputs usable in organic agriculture.*"

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