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CORRELATION BETWEEN SOME FOLIAR FERTILIZERS USED IN ORGANIC AGRICULTURE AND NITROGEN UPTAKE IN DIFFERENT CROPS AND GROWTH STAGES

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Abstract

The use of organic fertilizers is becoming more widespread, especially since an increasing number of farmers are reorienting to organic farming. However, on the market there is a relatively limited offer of these treatments compared to conventional fertilizers. Studying their efficiency is a domain still at early stages in our country. This study aims to determine the influence of a chelated complex fertilizer of micronutrients (Codamix) and an organic fertilizer based on proteins and seaweed (Ecoaminoalga), on the total nitrogen content of some crops. These foliar treatments were applied to wheat, maize, sunflower and soybean crops and the total nitrogen content of both leaves and seeds was determined. A control lot where no foliar fertilizers were used was also analysed. Both plant and fertilizer samples were analysed with CHNS Elemental Analyzer, after dehydration. Multiple differences were observed between the control group and the lots where foliar treatments were used, as well as correlations between the type of fertilizer and the nitrogen content for certain crops.

Key words: *crop nitrogen status, foliar fertilization, organic, CHNS elemental analysis.*

INTRODUCTION

One of the main concerns of fertilizer producers is to find a way to provide the nutrients needed by the plants at an optimal level. Nitrogen, as a vital element for plants, can be delivered through special nitrogen fertilizers, in different forms. In addition, some other nutrients can improve nitrogen use efficiency, so the key of a good fertilization is to find a balance between elements. In a detailed review, Rietra et al. (2017) describes the interaction between macro and micro nutrients for different agricultural crops, with the effect on yield quality and quantity, providing good knowledge for fertilizer design and optimization of fertilization strategies. Foliar fertilization has a series of advantages over conventional soil fertilization, especially when it comes to micronutrients. These elements are often inaccessible although their quantity in soil is sufficient. Micronutrients availability from soil to plants is influenced by a lot of factors such as the organic matter, soil minerals, redox potential, pH, soil microorganisms, enzymes and many more (Kurešová et al., 2019).

Many times, micronutrients are immobilized in soil, so using foliar fertilizers can improve the nutrients uptake (Haytova, 2013).

Brown et al. (2012) presents the perspectives of foliar fertilization as modern crop management and with lower environmental risk in contrast to soil applications. Also, foliar fertilizers can be mixed with many types of water-soluble pesticides, reducing the time and costs of crop production. (Kuepper, 2003).

Micronutrients have an important role in plant nutrition as they are essential for a normal development and for regulating many plant functions. Some studies showed that micronutrient foliar application increases the yield and quality of crops especially when used in addition to macronutrient classic fertilization (Tariq & Khalid, 2020; Dinu et al., 2019).

In another experiment on wheat crops, Mikos-Szymańska et al. (2018) showed that micronutrient foliar fertilisation combined with standard fertilisation significantly improved thousand grain weight (TGW) unlike standard soil fertilisation alone. No significant effects were mentioned on other yield indicators.
Stepien and Wojtkowiak (2016) reported that micronutrient foliar spraying contributed to a high proportion of proteins in wheat grain due to plant metabolism stimulation, but no significant difference was observed.
On sunflower crops, some studies also revealed that foliar micronutrient treatments improved some characteristics. Tegegnework el al. (2015) observed a significant efficacy of foliar applications on physical characteristics: height of plants, number of leaves per plant, leaf area, stem girth, minimum days to flowering, head diameter and total dry matter accumulation. Similar studies showed an improvement of the same physical indicators (Baraich et al., 2016; Keerio et al., 2020), but regarding the chemical composition, especially oil content, other studies found no significant differences when foliar micronutrients were applied (Škarpa et al., 2013; Rao et al., 2020).
The effects on maize crops were also studied, but the conclusions are unclear. Some works reported no differences on yield when foliar micronutrients were used (Mueller & Diaz, 2011; Sharma et al., 2018).
Another study by Yousefi (2012) pointed out that a foliar spraying with Zn, Fe and Mn improved the quality and quantity of the harvest in spite of the fact that TGW and cob weight increase was not significant. Also, a study by Stewart (2016) concluded that the foliar micronutrient applications have an unpredictable response on grain yield on some maize cultures in Nebraska, USA. The results showed both positive and negative response, in cases without visual signs of micronutrient deficiency on plants. He also recommends the foliar micronutrient fertilization only when evidence of mineral deficiency is observed. Similar conclusions were highlighted for soybean crops. Some works have concluded that foliar applications of micronutrients has no significant effect (Sutradhar et al., 2017; Lilley, 2020). Moreover, a study by Staton (2019), conducted in Michigan (USA) over the past 10 years, showed that foliar fertilizers application to soybeans is not recommended since the unfertilized control in 109 of the 117 trials was more profitable. But at the same time, other studies showed that some foliar fertilizers improved some crop characteristics as bean size, TGW and yield (Kolesar et al., 2020; Heidarzade et al, 2016). As Dimkpa and Bindraban (2016) concluded in a review about fortification of micronutrients for efficient agronomic production, is impossible to have a single product with a balanced composition of micronutrients, due the variation of soil composition, the different needs of the crops and the negative interaction that can occur between some nutrients.
This study aims to determine the influence of a chelated complex fertilizer of micronutrients (Codamix) and an organic fertilizer based on proteins and seaweed (Ecoaminoalga), on the total nitrogen content of four crops: wheat, maize, sunflower and soybean.

MATERIALS AND METHODS

A field experiment was conducted in 2020 at the Pitești Agricultural Development Research Station, Romania. The field is part of the West Romanian Plain situated on a terrace of Arges River at an altitude of 334 m (Răducu et al., 2009). The plant material was represented by four crops: wheat (Trivale variety), maize (F.376 hybrid), sunflower (Puntasol hybrid), and soybean (Florina F variety). For each culture, a one-factor experiment was conducted, consisting by three variants of treatments: V1 – Control variant (no fertilization); V2 – Foliar fertilization with Codamix; V3 – Foliar fertilization with Ecoaminoalga. Codamix is a water-soluble fertilizer which contains trace elements chelated by citric acid, lignosulphonic acids and EDTA. It is used often a supplement to NPK fertilising schedules (Sustainable Agro Solutions, Codamix producer, 2021). Ecoaminoalga is an organic fertilizer obtained from soy and seaweed protein hydrolysis with over 40% organic matter and peptides content. It is recommended for use in organic farming .
The treatments were applied on 25 June 2020, using 2.5 L/ha for both fertilizers. For each culture, two types of samples were taken: leaf samples from medium stage of development and

grain samples from the moment of harvest. The plant samples and the sampling moments are presented in Table 1. For each sample, three replicates were taken.

Table 1. The plant samples used for analyzes

Crop	Plant part	Date of reception
Wheat	Leaves	04.06.2020
	Grains	28.07.2020
Maize	Leaves	02.07.2020
	Grains	07.09.2020
Sunflower	Leaves	02.07.2020
	Grains	07.09.2020
Soybean	Leaves	02.07.2020
	Grains	20.10.2020

All plant samples were dried to constant mass, ground with the laboratory grinder into fine powder and kept in desiccators until analysed.
An amount of 1-3 mg of sample was used to determine the total nitrogen content. The analysis was performed using the CHNS elemental analyzer (EuroVector EA3100 Elemental Analyzer). Cystine was used as standard reference material. All determinations were performed in three repetitions. The fertilizers were also analyzed for total nitrogen content. The values represent the mean of three determinations (Table 2).

Table 2. Nitrogen content of used fertilizers

Fertilizer	Nitrogen content (%)
Codamix	0.230
Ecoaminoalga	3.520

All the analyses for this study were made using the infrastructure of Research Center for Studies of Food Quality and Agricultural Products, University of Agronomic Sciences and Veterinary Medicine of Bucharest.
The obtained data were processed using IBM SPSS statistical software. Duncan's Multiple Range Test at $P \leq 0.05$ level was used for significance determination between groups of means of the three variants used in the experiment. The bars in the charts represent the means±SE of each variant. The same letters above each bar means that they are not significantly different.

RESULTS AND DISCUSSIONS

This study follows only the changes of nitrogen content in mentioned crops when the mentioned foliar fertilizers are used. Although the fertilization effects usually can be observed on quantitative measurements of crops, also qualitative improvement may occur (as the content of proteins, minerals, fats, etc.).

The effect on wheat crop
The wheat leaves from both fertilized variants showed a significant higher content of nitrogen compared with the control variant (Figure 1). An increase of 21.55% and 29.87% over control variant was observed in case of Codamix fertilization and Ecoaminoalga, respectively.

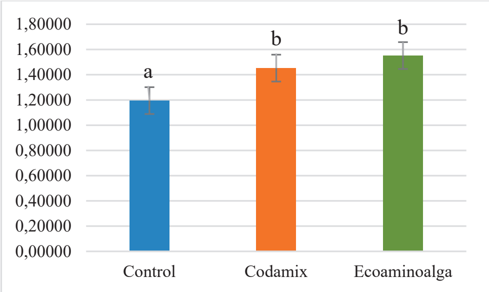

Figure 1. Nitrogen content in wheat leaves (% in DW) .

The wheat grain also showed a significant difference on nitrogen content between control and fertilized variants. The nitrogen increased with 29.83% and 41.84% using Codamix and respectively, Ecoaminoalga fertilizer (Figure 2).

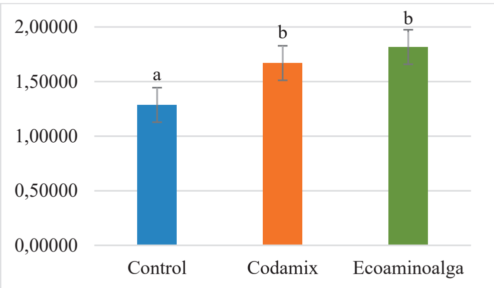

Figure 2. Nitrogen content in wheat grains (% in DW).

Even these fertilizers have a small quantity of nitrogen compared with special nitrogen fertilizers, it can be observed that both the leaves and the grains have accumulated a significant amount of nitrogen compared to the control. Also, the content of nitrogen of V3 samples (Ecominoalga) slightly exceeds the V2 samples (Codamix), but not significantly. This difference may occur due the higher nitrogen content on Ecoaminoalga fertilizer.

The effect on maize crop
Unlike the wheat, maize crop had a different response to micronutrient foliar applications regarding the nitrogen uptake. There are no significant difference between the control and Ecoaminoalga fertilization on maize leaves. On the contrary, a slight decrease in nitrogen can be observed on Ecoaminoalga variant. This direction was noticed by another study on maize crops when foliar micronutrients were used (Stewart, 2016). This insignificant decrease was attributed to the toxic effects of some micronutrients to leaves. However, the Codamix variant recorded a significant increase by 14.41%, compared to the control (Figure. 3).

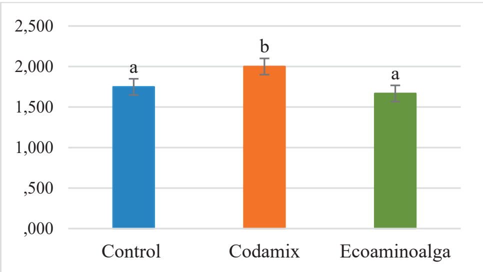

Figure 3. Nitrogen content in maize leaves (% in DW).

Regarding the nitrogen content in maize grains, there are no important modification between control and both the fertilized variants (Figure 4).

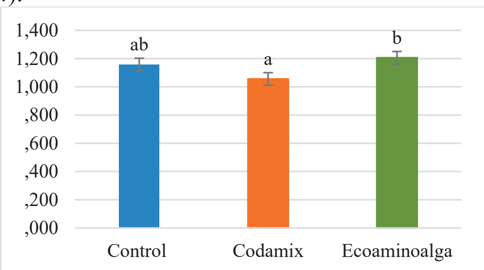

Figure 4. Nitrogen content in maize grains (% in DW).

Still, a difference between fertilized variants can be noticed. An interesting fact is that the nitrogen content in leaves was 20% higher on Codamix variant in summer, but the grains harvested in autumn had a bigger nitrogen content (14.2%) on Ecoaminoalga variant. This may be due to different micronutrient content in fertilizers, which can change the nitrogen use efficiency.

The effect on sunflower crop
The results on sunflower were almost invisible regarding the nitrogen uptake. No notable difference was observed neither to the leaves (Figure. 5), nor to the seeds (Figure. 6).

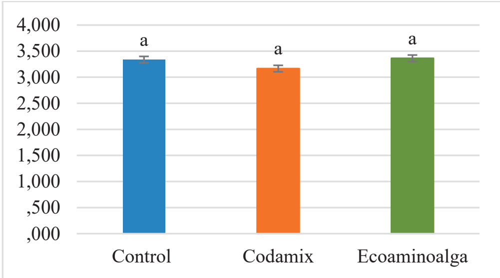

Figure 5. Nitrogen content in sunflower leaves (% in DW)

This does not mean that foliar applications are not useful. On the contrary, as pointed out earlier, a lot of physical characteristics were improved using this type of fertilization. But the advantages over the chemical composition are still unclear.

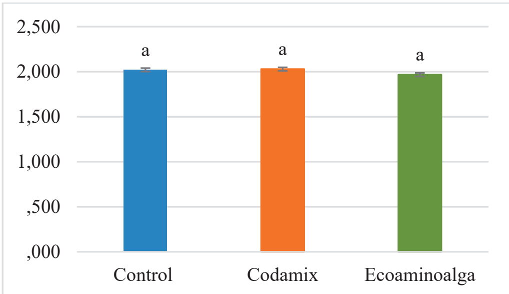

Figure 6. Nitrogen content in sunflower seeds (% in DW)

The effect on soybean crop
Regarding soybean, although the nitrogen uptake of leaves was significantly higher on fertilized crops (by 13.12% on Codamix variant and 22.36% on Ecoaminoalga variant) compared both control crop (Figure. 7), the nitrogen content did not differ much in soy beans from all variants (Figure. 8).

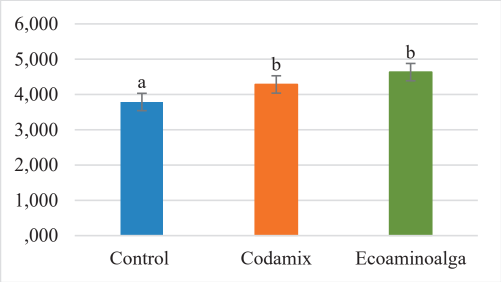

Figure 7. Nitrogen content in soybean leaves (% in DW)

Moreover, a slightly decrease was observed both on Codamix variant and on Ecoaminoalga variant, the same as observed in the case of maize crops. As in related studies, the foliar fertilizers did not produce promising results regarding nitrogen content. But also, some other characteristics may be improved using these type of application.

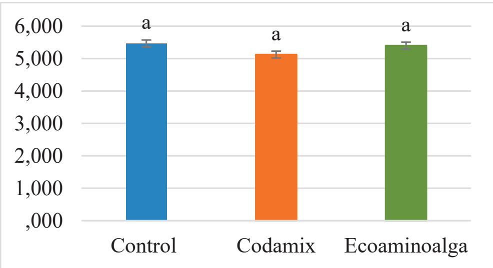

Figure 8. Nitrogen content in soy beans (% in DW)

CONCLUSIONS

The foliar micronutrient fertilization have an unpredictable response to nitrogen uptake on different crop types.

On wheat, the nitrogen uptake was clearly superior when foliar fertilizers were used, especially when the nitrogen content of fertilizer was higher.

On maize crops, the foliar fertilization has no noticeable effect on grain nitrogen content, but may increase the yield. This aspect was not followed in this paper.

Also, the same response was achieved for sunflower crop, with no increase in nitrogen content on fertilized variants.

On soybean, the nitrogen uptake was well observed on leaves collected in summer, but on the beans harvested in autumn the nitrogen content was not significantly different from the control crop.

Concluding, the type of crop has an important influence on fertilizer efficiency. An optimal foliar fertilizer must take into account the needs of the plant but also the water and nutrient uptake capacity of the leaves. These aspects, together with other factors such as soil characteristics, climate are responsible for the efficiency of different fertilizers.

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