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SOYBEAN RESPONSE TO FOLIAR AND SOIL FERTILIZATION

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Abstract

The objective of this study was to investigate the effect of foliar fertilization as compared to mineral fertilization on yield and yield components of soybean. The experiments were carried out during 2020 and 2021 growing seasons at Research and Development Station for Agriculture Turda (RDSA Turda), Romania, using randomised complete block design with three replications. The two variants of foliar fertilization contain macro and micro elements, being applied in different phases of soybean growth and development. Among the foliar fertilization options, T_1 stood out as the foliar fertilization option that contributed to some extent to the growth of plant height, the number of pods/plant, the number of grains/plant, the weight of grains/plant and yield. The second variant of foliar fertilization (T_2) in most of the analysed cases determined a decrease in the yield elements as well as the yield compared to the control variant.

Key words: *foliar fertilization, genotypes, mineral fertilization, productivity elements, yield.*

INTRODUCTION

Godfray et al. (2010) estimated that worldwide food demand will continue to grow for the next 40 years. Soybean is considered one of the most important crops nowadays, being cultivated on millions of hectares around the world (Bueno et al., 2020). It should be noted that it is a major source of vegetable protein worldwide due to its high quality and relatively low production cost (Brzostowski et al., 2017).

Several authors Engy et al. (2020), Diacono et al. (2013), Piccinin et al. (2013) stated that fertilization is one of the most important factors that limit plant productivity, and nitrogen, phosphorus and potassium are essential and important nutrients in the growth and development of plants.

According to Nendel et al. (2019), nitrogen is a macronutrient required in large quantities, because it is more reduced in the soil chemical composition, thus, it must be supplemented by fertilization (Kebeney et al., 2015). Phosphorus deficiency also affects the intrinsic efficiency of nutrient use and the dynamics of other nutrients such as nitrogen (Singh et al., 2019). Potassium is one of the important macro elements for plants, with a role in forming yield and determining quality, being involved in many physiological processes (Liu et al., 2022).

Also, micronutrients play an important role in the physiology of the plant, contributing together with the main nutritional elements in the forming of yield and its quality. Since they are found in smaller quantities in the soil, applying foliar fertilization can supplement the essential micronutrients required for optimal plant development.

In the absence of micronutrients, the plant presents physiological disturbances that lead to low crop yield. High yields and quality especially, oil content, were obtained by fertilization with micronutrients (Jadhav et al., 2019).

The number of solutions available to farmers for foliar application has increased in recent years. These solutions are often promoted as having the potential to increase yield (Slaton et al., 2014).

Foliar fertilization is an alternative approach, micronutrients can be absorbed from liquid form into plants (Nasiri et al., 2010). Camberato et al. (2010) mentioned that, if micronutrient deficiencies occur during the vegetative growth phase, the most effective method to overcome these deficiencies is through the application of foliar fertilizers.

According to Zayed et al. (2011), Paikra and Lakpale (2018) foliar application with trace elements is more beneficial than soil application due to its lower doses compared to soil application.

Mallarino et al. (2005) reported that foliar fertilization in the early vegetative stages of soybean increased yield from 15% to 30% depending on climatic conditions.

Previous studies have indicated that foliar fertilization of soybean is justified, and the effects of fertilizer application depend on certain factors, such as crop technology but also the climatic conditions during the vegetation period (Jarecki et al., 2016; Odeleye et al., 2007).

Slaton et al. (2014) stated that although a substantial amount of research has been conducted on foliar fertilization, with different types of fertilizers and application methods, new products continue to be developed, requiring further research to investigate the benefits and their potential.

MATERIALS AND METHODS

The two-year (2020, 2021) field experiment was carried out at Research and Development Station for Agriculture Turda (RDSA Turda), Romania, which is located between 46°35' N latitude, 23°4′ E longitude, with an altitude of 427 m above sea level.

The soybean genotypes selected for the trial include 75 genotypes and each soybean variety was sown in the second decade of April at a seed rate of 55 germinating seeds m^{-1}.

The soil type is faeozem vertical soil with a content in humus of 3.5%, mobile phosphorus 4.5 mg P_2O_5/100 g soil (AL), mobile potassium 30 mg K_2O/100 g soil (AL) and the soil reaction is characterized as neutral.

The experimental design was a complete randomised block with three replications each soybean genotypes being sown on two rows, 12 m length and 50 cm distance between rows with the harvested plot of ten square meter. To avoid border effect one square meter of every side in each plot was not considered for harvest.

The climatic data for the period of growing seasons from April till October (2020 and 2021) were records by RDSA Turda meteorological station.

The climatic conditions of the two experimental years (2020, 2021) were different regarding temperature and distribution of rainfall during the vegetation period of the soybean crop. The deviations recorded in the spring months (April, May) both in 2020 and 2012 indicate a decrease in temperature and rainfall with a negative effect on the emergence of the soybean crop in optimal conditions (Figures 1, 2).

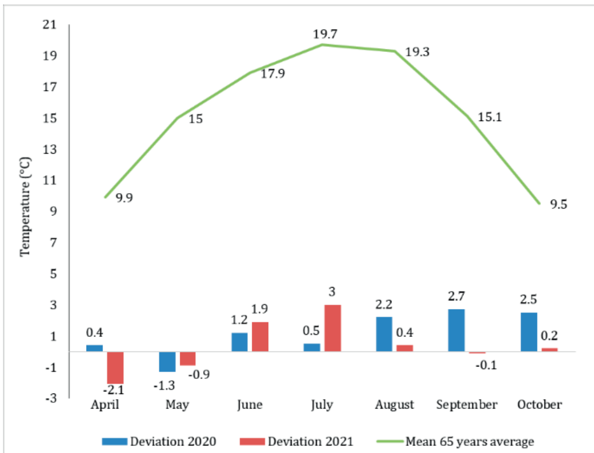

Figure 1. Temperature deviations from the average, recorded in the experimental years 2020, 2021

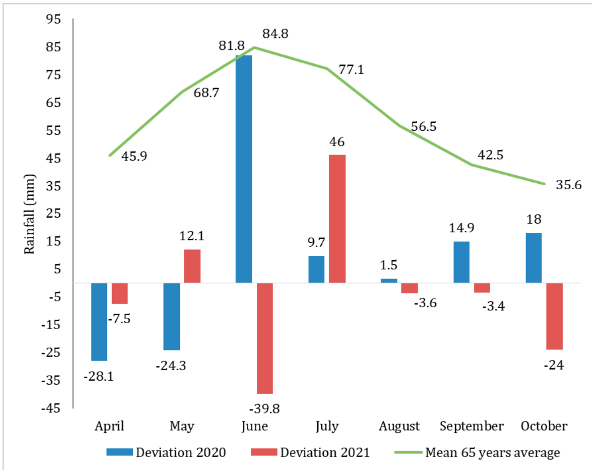

Figure 2. Rainfall deviations from the average, recorded in the experimental years 2020, 2021

In the summer months, positive temperature deviations are recorded, more significantly in 2021. The increase in temperatures in the summer months affects the soybean reproductive phase, to some extent, but the rainfall recorded, with positive deviations above the multi-year average, reduces the negative effect of high temperatures.

Thus, depending on the year, the climatic conditions have a high influence on the yield and quality of the soybean crop, which can be reduced by technological measures, for example, fertilization.

The three experimental variants of fertilization used are represented in Table 1.

Table 1. The experimental variants of foliar and soil fertilization

Treatment variant	Control	T_1	T_2
Applied before sowing	✓	✓	✓
Six trifoliate leaves*		✓	✓
Beginning blooming*			✓

*The vegetative (V) and reproductive (R) stages were noted using a worldwide standard descriptors methodology proposed by Fehr and Caviness (1977).

Control: Basic fertilization (mineral), contains 27% total nitrogen, 13.5% nitric and ammoniacal nitrogen and micro elements such as CaO 7% and MgO 5%.
T_1: Foliar fertilization I, a single product having 80% w/w free amino acids, Total Nitrogen (N) 12.8% w/w and Organic Nitrogen 12.8% w/w.
T_2: Foliar fertilization II with two products, contains K_2O 25% w/w - 38% w/v and Boron (B) soluble in water 9% w/w, Molybdenum (Mo) soluble in water 1% w/w and soluble extracts from seaweed (*Ascophyllum nodosum*).
Mineral fertilization was applied mechanically with the fertilization equipment and foliar fertilization with macro and micronutrients was applied manually with the back pump on the leaves of the plants.
At the physiological maturity of each variant, ten plants were randomly extracted to determine the productivity elements. The extracted plants were manually threshed to analyse the productivity elements (measured and counted), individually depending on the genotype and the fertilization variant.
An analytical balance was used to determine the TKW and the weight of the grains/plant, and after the mechanized harvesting of the experimental plots, the analytical balance was also used to weigh the yield/plot, finally, yield was reported per hectare.
The recorded data for yield and yield components were subjected to statistical analysis using Microsoft Excel and Anova PoliFact Soft.

RESULTS AND DISCUSSIONS

The foliar treatments applied slightly increased plant height, in 2020, T_1 being more efficient compared to T_2 (Figure 3). Therefore, it can be observed that T_1 (fertilization before sowing + foliar fertilization before flowering) caused a slight increase of 2.25% in plant height as compared to T_2 (fertilization before sowing + foliar fertilization before flowering + foliar fertilization at blooming), which decreased plant height by 1.12%.

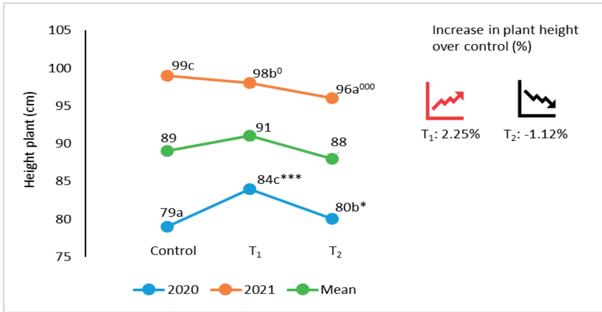

Figure 3. Effect of foliar application on the plant height of soybean during growing seasons 2020, 2021

Veneziano et al. (2021) stated that in 83% of cases the foliar fertilized increased plant height and yield, following the experiments carried out in different regions of Brazil.
Dass et al. (2021) in a three-year study state that the plants had a higher height with the foliar application of urea 2%, DAP 2%, and NPK 2%, and at the same time others foliar application with different nutrients did not increase the height of the plants.
In the case of the insertion height of the first basal pod, the foliar fertilizer applied increased this important character for mechanized harvesting with minimal losses.
The effect of foliar fertilization on the insertion height can also be observed by the percentage of 7.14% increase over control (Figure 4). Although the growth is, on average, only one cm, it seems that the products used, in the two-year analysis, have a positive influence on insertion height.

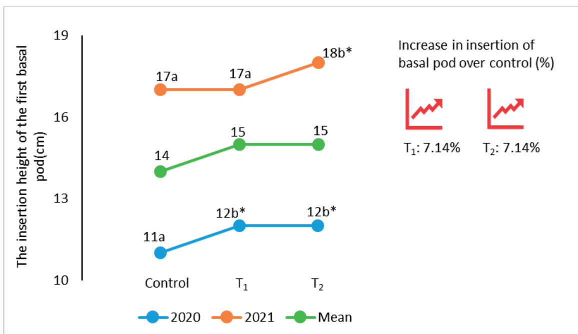

Figure 4. Effect of foliar application on the insertion of first basal pods of soybean during growing seasons 2020, 2021

The number of pods/plant was lower in the first experimental year (2020) as compared to 2021 (Figure 5). Although the climatic conditions of 2020 resulted in the formation of a lower number of pods/plant, T_1 contributed to a slight increase in this yield component. The number of pods/plant at control was similar to T_1, T_2 slightly reduced this character (-5.56%).

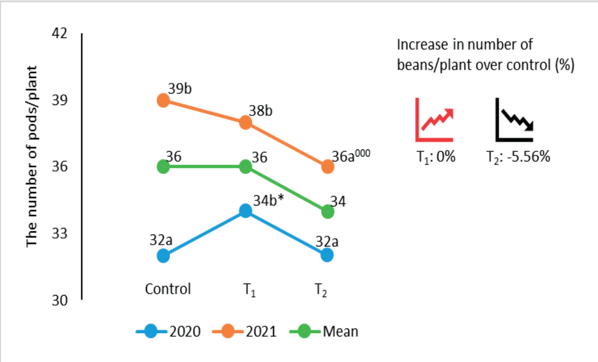

Figure 5. Effect of foliar application on the number of pods/plant of soybean during growing seasons 2020, 2021

The application of foliar fertilization with Zn 0.5%, B 0.5% and urea 2% at the beginning of pod formation significantly increased the number of pods/plant (Dass et al., 2021).
Galeriani et al. (2022) following the experience with the foliar application of Ca + B stated that this led to an increase in the number of pods and yield. Souza et al. (2022) in the foliar experiment with B states that regardless of the time of boron application, it did not have a significant effect on the number of pods/plant, number of flowers and yield.
According to Sachin et al. (2022) the foliar application of nutrients with potassium nitrate 2% + boric acid 50 ppm significantly influenced the number of pods/plant, number of grains/pod and weight of grains/plant.
In 2020, the T_1 foliar fertilization contributed to an increase of grains/plant, also confirmed by the average of the 2-year experience (Figure 6). Although, in 2021 there was a higher number of grains/plant compared to 2020, the two variants of foliar fertilization did not influence the increase in number of grains/plant, an obvious decrease is observed in the case of T_2, having a negative effect on this character of 4.82%.
The weight of grains/plant also contributes to the formation of yield, although the values obtained in the two years are quite close (between 12-13 g/plant), T_1 increased grains weight/plant with 1.31% as compared to control (Figure 7). In both years T_2 did not lead to an increase of grain weight/plant, the decrease being of 5.58% as compared to the control.

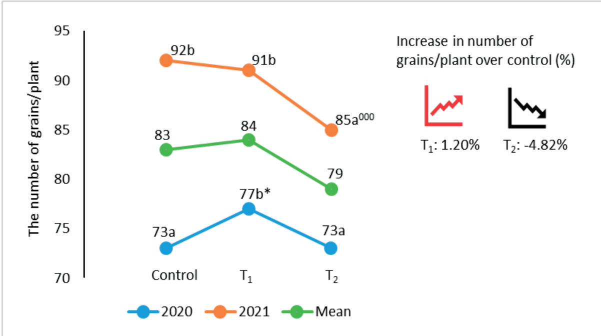

Figure 6. Effect of foliar application on the number of grains/plant of soybean during growing seasons 2020, 2021

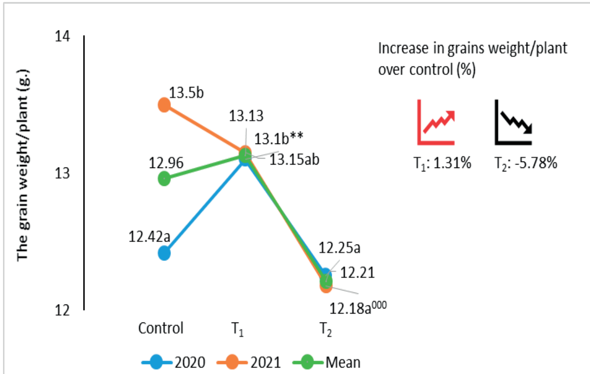

Figure 7. Effect of foliar application on the grain weight/plant of soybean during growing seasons 2020, 2021

Regarding TKW, it appears that the different foliar fertilization options did not lead to an increase as compared to basic fertilization (Figure 8).
The highest values of TKW were recorded in 2020, with an average of 172 g, the two foliar fertilization options had similar values, 172.7 g, respectively 168.8 g.

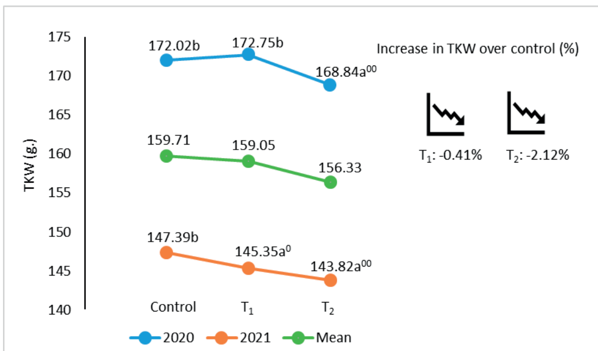

Figure 8. Effect of foliar application on the TKW of soybean during growing seasons 2020, 2021

In other studies, the application of boron in the stages of V4, R1 and R3 led to an increase of the TKW (Souza et al., 2022).

Like TKW, the most quantitatively significant yields were recorded in 2020 compared to 2021, the differences between the fertilization options being approximately 400 kg/ha (Figure 9).

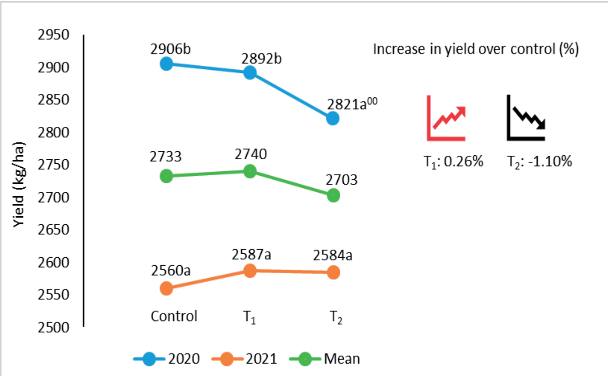

Figure 9. Effect of foliar application on the yield of soybean during growing season 2020, 2021

On average, it can be observed that in the two-year study, the yield of the fertilization variants was over 2700 kg/ha, depending on the climatic conditions, foliar fertilization can positively or negatively influence the yield.

Dass et al. (2021) stated that soybean foliar fertilized with Zn 0.5%, B 0.5%, NPK 2% and urea 2% led to a significant increase in grain yield compared to the control variant with increases of 18-37, 16-23, and 14-23%, respectively. Regarding yield, foliar fertilization with B, regardless of the time of application, did not cause an increase in yield (Souza et al., 2022).

CONCLUSIONS

Among the foliar fertilization options, T_1 stood out and contributed to some extent to the growth of plant height, the number of pods/plant, the number of grains/plant, the grains weight/plant and yield.

However, among these elements that reacted positively to the application of the T_1 fertilization variant, having a higher percentage than the control, are: plant height 2.25%, number of grains/plant 1.20% and grains weight/plant 1.31%. Also, for the number of pods/plant and yield, although T_1 contributed to an increase, this is within narrow limits, 0% and 0.26%, respectively.

The second variant of foliar fertilization (T_2) determined a decrease in the yield elements as well as the yield compared to the control variant. The 1000 grain weight (TKW) is negatively affected by the application of foliar fertilizers, and regarding the height of the first basal pod insertion, both variants of foliar fertilization determined an increase of 7.14% over the control.

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