Influence of foliar fertilization on productivity elements and quality indices on different soybean genotypes

(SUMMARY OF Ph.D. THESIS)

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INTRODUCTION

GODFRAY et al., (2010) estimate that worldwide food demand will continue to grow for at least 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). Soybean is a high consuming plant of nutrients (especially nitrogen, but also phosphorus and potassium) this is due to the high protein and fat content of the grain (MUNTEAN et al., 2014).

Macro and micronutrients are important for the growth and development of soybean plants, and most of the assimilated nutrients are exported to the grain, as stated by MAEHLER et al., (2003). According to RUSU, (2020) the effective use of foliar fertilization requires knowledge to establish their application based on integrated and differentiated fertilization systems with sustainability of the agricultural system. Through a correct use, conditions can be created to involve the effect and the differentiated but particular role of each element in their complex composition.

Due to the wide range of use of the soybean crop, but especially the particularities that designate it as a high-value protein crop, it has led to the expansion of the areas crop with soybeans worldwide. This fact has generated a special interest in cultivation technology, but especially in an important technological link such as fertilization. Knowing that soybean is a great consumer of nutrients and foliar fertilization is a sure measure to supplement mineral fertilization, we wanted to see the effect of foliar fertilization on the quantitative and qualitative characteristics of soybean.

Thus, in order to come up with some clarifications related to the response of some soybean genotypes from different maturity groups to the application of foliar fertilizers, during the experimental years 2020, 2021 at the Research and Development Station for Agriculture Turda an experiment was set up where 75 soybeans genotypes were analyzed from the point of view of yield elements, yield and qualitative indices when applying some variants of foliar fertilization compared to the control variant represented by mineral fertilization.

The researches carried out during the doctoral thesis are useful and very up-to-date, at the same time they bring particularly relevant information regarding the reaction of soybeans to different types of fertilization, mineral and foliar, which can lead to an increase in the yield and quality of the soybean crop.

The PhD thesis with the title "Influence of foliar fertilization on productivity elements and quality indices on different soybean genotypes" is balanced and structured in two parts and nine chapters.

The first part: LITERATURE REVIEW, is structured in three chapters that present important aspects from the specialized literature studied.

The second part: PERSONAL CONTRIBUTION, combines theoretical and methodological aspects with practical ones and is structured in six chapters. Chapters five, six and seven, to which the general conclusions, recommendations, originality, bibliography are added, represent the largest part of the work.

1. Literature review of research on the importance of soybean culture

Chapter 1 includes three sub-chapters in which current information is presented on: the importance of soybean crop and its chemical composition, the history of soybean crop, the geographical distribution of the crop; soybean crop worldwide and soybean crop in Romania.

2. The ecological areas of soybean crop in Romania and the requirements for climate and soil

Chapter 2 comprises two sub-chapters dealing with ecological areas and climate and soil requirements.

3. General aspects of soybean crop and its fertilization

Chapter 3 includes three sub-chapters in which the particularities of the soybean crop are presented, essential elements in the management of the soybean crop and the fertilization of the soybean crop; foliar fertilization.

4. Research objectives

Chapter 4 includes the objectives of the research which had as the main aim of the research the quantification of the reaction of some soybean genotypes to some foliar fertilization variants. From these objectives, results emerged that allowed the development of agronomical valuable conclusions and recommendations both for research and for the farmers of the Transylvanian Plain.

5. The particularities of the natural environment in which the experiment took place

Chapter 5 presents: relief, hydrography, climate, temperature, precipitation and soil in the crop area where the experiment was located.

6. Material and method

Chapter 6 presents the description of the biological material used, the method of placing the experiment in the field, the experimental factors, the research methods, the observations and analyzes performed, the chemical materials used. In this experiment we analyzed 75 soybean genotypes from four maturity groups; 15 genotypes each from the very early (000), semi-early (0), semi-late (I) maturity groups and 30 from the early maturity group (00). Of the 75 genotypes, 28 are of local origin (20 varieties and three perspective lines created at RDSA Turda and five varieties created at NARDI Fundulea) and 47 are genotypes from different European countries (Austria, Croatia, Switzerland, Italy, France, Serbia and Germany).

7. Results and discussion

Chapter 7 is structured in 4 sub-chapters and 12 sub-sub-chapters that present the results obtained in the experiment that tracked the influence of foliar fertilization on some morphological features, agronomic components of production, the behavior of genotypes through the yield and quality indices of the genotypes studied from the four maturity groups (very early, early, semi-early, semi-late).

The effect of foliar fertilization on morphological characteristics such as plant height, insertion height of the first basal pod and the number of nodes/plant at the 75 studied genotypes was different in the two experimental years, due to the fact that the genotype is in control of these characteristics.

If we refer to the influence of the three experimental factors (year, fertilization and maturity group) on plant height, we can state that maturity groups and climatic conditions determine the most important variations of this characteristic. Remarkable differences can be observed between the maturity groups, the genotypes from the very early group have the lowest plant height and the most significant values are in the later groups.

For the insertion height of the first basal pod, among the three factors analyzed, as in the case of plant height, the climatic conditions and the maturity group stand out. Thus, the genotypes from the maturity group I have a higher insertion height compared to the genotypes from the maturity groups 000, 00 and 0, which show fairly close values.

Regarding the number of nodes/plant, climatic conditions, fertilization and even maturity groups did not significantly influence the number of nodes/plant. Moreover, the number of nodes/plant varied

between very low limits, overall, the maturity groups have the same behavior with the exception of the very early group.

In the case of the main components of yield, foliar fertilization had a slight contribution in increasing their number or even a negative effect. The number of pods/plant was not influenced by the climatic conditions during the experimental period, between the two variants of foliar fertilization it seems that the Ff_2 variant causes the formation of a smaller number of pods/plant and among the maturity groups analyzed, the later groups had a higher number of pods/plant compared to the early ones.

The climatic conditions of the two years of experimentation did not significantly mark the average number of grains/plant compared to the control represented by the average of the years, although between the two years there are remarkable differences regarding this attribute, thus in 2021 the average number of grains/plant is 16 higher compared to the year 2020. In contrast to the climatic elements, the technological factors represented by the two variants of foliar fertilization do not adjust in a very convincing way the number of grains/plant, Ff_2 determining a number of grains/plant more small, and with the highest number of grains/plant again the later maturity groups stand out.

On the weight of the grains/plant, the climatic conditions of the years of experimentation had no influence on this character. From the analysis and processing of the experimental data, it appears that in the case of this character as well as in the situation of the number of pods/plant and the number of grains/plant, Ff_2 has a distinctly significantly negative influence. The behavior of the genotypes from the early maturity group in terms of the weight of the grains/plant, supports the statement that the genotypes that have a vegetation period that allows them to be included in this group, are the best adapted to the climatic conditions of the Transylvanian Plain area.

An important element that contributes to yield is the mass of 1000 grains (TKW). The favorable climatic conditions in the experimental year 2020 positively influenced the size and weight of the grains, the difference compared to the control being very significantly positive, on the other hand, in the year 2021 the climatic conditions were less favorable to the process of filling the grains, so that the TKW recorded lower values, the difference compared to the control being very significantly negative. Of the two variants of foliar fertilization, it seems that Ff_2 has distinctly significantly negatively influenced the TKW, although the differences compared to the control are quite small. The differences recorded at the level of maturity groups suggest that in the Transylvanian Plain, the best adapted in terms of

grain size are the genotypes that belong to the early and very early groups, the differences recorded in these two groups being very significantly positive compared to the control.

Regarding the influence of the experimental conditions on grain yield (kg/ha) from the two experimental years, it was found that the year 2020 was more favorable to the expression of the productive potential, the difference compared to the control being significantly positive, and the year 2021 marked a significant negative average soybean yield. Regarding fertilizations, no significant influence on yield is observed except for the second foliar fertilization option (Ff_2), which seems to have significantly reduced yield overall. Depending on the maturity group, the yield registers increasing values from the early groups to the late groups.

For a clearer highlighting of the effect of foliar fertilization on yield, we analyzed the separate behavior of maturity groups to foliar fertilization and according to the experimental data that showed the interaction between fertilization and genotype, we could say that the genotypes showed an individual reaction to the application of fertilizers. Also, it cannot be stated that for most genotypes the application of foliar fertilizers determined the obtaining of significant quantitative gains compared to mineral fertilization.

Regarding grain quality, quality indices have a polygenic determinism with mostly additive actions, being considerably influenced by climatic and technological conditions. On the protein content, even though the differences are very close compared to the average of the experimental years, the year 2020 registered a significantly negative influence and the year 2021 had a significantly positive influence on this qualitative characteristic. Related to the fertilization variants, there is a very significantly negative difference in the case of Ff_1 compared to the control and Ff_2 which had a distinctly significantly positive influence in terms of protein content. The late maturity groups have a very significantly negative influence on the protein content compared to the early ones because it is known that there is a negative correlation between yield and quality.

For the fat content, the climatic conditions of the experimental year 2020 determined the favorable show of this quantitative character, with a very significantly positive difference, and the year 2021 was not favorable in the expression of this character, having a very significantly negative difference compared to the average of the years. The fertilization factor has no influence on this qualitative index, although the differences are small, the late maturity groups have a very significantly positive influence and the

early ones distinctly and very significantly negative compared to the average of the groups. Regardless of the maturity group, the value of the fat content is around 22%.

The essential fatty acids present in soybeans are the types of important dietary fats with multiple benefits to human health. Palmitic (11%), stearic (4%), oleic (25%), linoleic (52%) and linolenic (8%) acids are the five major fatty acids in soybean oil.

Regarding the influence of the experimental conditions on the stearic acid content of the two experimental years, although the differences are narrow, it was found that the year 2020 was more favorable on the stearic acid content, having a very significantly positive influence compared to the average years and the year 2021 which had a very significantly negative influence. The foliar fertilizations applied compared to the control, although they have a small difference, had a very significantly positive influence on this qualitative index. Among the analyzed maturity groups, the earliest ones stand out as having a very significantly positive influence compared to the average of the groups, and the later groups had a very significantly negative influence.

In the case of the linolenic acid content, the year 2020 stood out as having a distinctly significantly positive influence compared to the average of the years, but with a slight difference, the year 2021 had a distinctly significantly negative influence. The fertilization factor stands out in the case of this qualitative index having a significant (Ff_1) or very significantly positive influence (Ff_2) compared to the control. The maturity groups studied and which stand out with a very significantly positive influence are the early and semi-late ones, and for the very early and semi-early maturity groups compared to the average of the groups, they had a very significant, respectively significantly negative influence on the linolenic acid content.

And in the case of protein content, for a clearer highlighting of the effect of foliar fertilization on this important qualitative index, we analyzed the separate behavior of maturity groups at foliar fertilization, and following these observations regarding the behavior of genotypes in terms of protein content at fertilization foliar, we could conclude that most of them registered statistically assured increases compared to the control at Ff_2 and only a fairly small number reacted favorably to Ff_1.

In order to identify possible genotypes with a high degree of yield stability, we resorted to the correlation of the annual yields, respectively those of 2020 and 2021. The correlation of the annual values can be seen as an estimate of the repeatability of the yields, and the value of the correlation coefficient „r" indirectly suggests the heritability of this

important quantitative trait with a particularly complex genetic determinism. In this sense, we aimed to observe the behavior of the genotypes from the maturity groups analyzed in the three types of fertilization and their influence on the stability of yields.

Regarding the stability of the yields, it is very difficult to nominate some genotypes with a high general adaptability, considering that the yield is a complex characteristic in the achievement of which several quantitative characteristics participate, each having its own genetic determinism. It is also known that yield is strongly influenced by environmental conditions as well as technological elements.

Thus, following the data processed regarding the stability of yields, foliar fertilization represents an important measure to stabilize soybean yields in the case of very early genotypes, although the genotypes have a rather particular behavior with foliar fertilization. For the early genotypes, most are placed in quadrants III and IV both under the conditions of mineral and foliar fertilization. Regarding the stability of the yields of the genotypes from the semi-early maturity group, they showed a rather uneven behavior in the two variants of foliar fertilization. The application of the Ff_1 fertilization variant did not cause a very significant change in the stability of the semi-late genotypes. The application of the variant with the two foliar fertilization somewhat narrows the yield distribution of semi-late genotypes, most genotypes, namely six, were located in quadrant IV.

8. Conclusions and recommendations

Chapter 8 is structured in 5 sub-chapters and includes the conclusions and recommendations based on the research carried out in the framework of the experiment located in 2020, 2021 at SCDA Turda.

The analysis of the influence of the three experimental factors on plant height shows that maturity groups and climatic conditions determine the most important variations of this characteristic.

Regarding the insertion height of the first basal pod, we can state that the two fertilization options with foliar fertilizers did not have a positive effect on this trait.

Under the conditions of RDSA Turda, in the two experimental years, the factors fertilization and maturity group had a very significant influence on the number of pods/plant, and the climate factor determined only a significant influence of this quantitative characteristic.

The differences recorded between the two experimental years indicate the important contribution of the environment in achieving the

number of grains/plant, and the technological factors represented by the two variants of foliar fertilization do not adjust the number of grains/plant in a very convincing way, the differences if we refer to control.

Foliar fertilization does not have a major impact on TKW compared to mineral fertilization, but in certain environmental conditions it can favorably influence this important quantitative attribute and can contribute in this way to the qualitative improvement of harvests intended for human consumption.

Regarding fertilizations, no significant influence on yield is observed except for the second foliar fertilization option (Ff_2), which seems to have significantly reduced yield overall.

The highest values of the protein content are in the early maturity groups, and the lowest in the late maturity groups. Ff_1 determined the reduction of the protein content of the analyzed genotypes within the early maturity groups, having a very significantly negative influence, and Ff_2 had a distinctly significantly positive and even very significantly positive influence.

The fertilization factor has no influence on the fat content, on the other hand, although the differences are small, the late maturity groups have a very significantly positive influence and the early ones distinctly and very significantly negative compared to the average of the groups.

Recommendations:

Considering the thermal potential of the area, we recommend that the varieties from group I that are to be cultivated, be in a smaller number. Sometimes their vegetation period can be extended until late autumn and if the succeeding plants are fall cereals their optimal sowing period is definitely passed.

In the last period, the climatic differences of the agricultural years are very pronounced, a fact that also affects the yield oscillations from one year to another. In order to limit to some extent this productive oscillation, we should identify genotypes with a high general and specific adaptability, and through the proposed technological measures to improve the adaptability of the cultivars.

A test of the foliar products used would be required before they are used on a large scale in the farm, in order to be able to make the most favorable decisions depending on the response of the varieties used regarding the protein content seen from the perspective of yield.

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