PhD THESIS

Productive and qualitative evaluation of some soybean genotypes of European and Asian origin, cultivated in conventional system

(SUMMARY OF THE PHD THESIS)

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INTRODUCTION

The importance of soybean cultivation (*Glycine Max Merill* L.) is related to the versatility it has, being successfully used in the food industry, in animal husbandry as protein feed for animals, for biofuel as a raw material, being also a very good precursor for most autumn cereals, especially for wheat. Therefore, the researchers have as a priority objective the creation of varieties adapted to stress conditions, performing, and with a quality corresponding to the dynamism of the market requirements.

The evaluation of cultivars in various pedo-climatic conditions is of particular importance in establishing the ecological adaptability of varieties and the most favorable growing areas. Testing soybean varieties in different years allows the identification of genotypes with high ecological plasticity, capable of capitalizing on each set of environmental conditions, by achieving productions close to the biological potential of the variety.

Interest in soybeans has increased, and research activity on this crop has been intensified, due to the growing demand for soybeans in the industry.

The choice of varieties by farmers must be made according to the maturity of the genotype and the pedoclimatic conditions in which the crop is to be established, the destination of the harvest.

In general, in areas known for limited thermal potential, it is recommended to grow earlier varieties, which need a low thermal requirement and manage to reach maturity in a timely manner, while for warm and very warm areas, genotypes with a longer vegetation period and a higher need for the sum of useful grades are favorable.

The doctoral thesis entitled "Productive and qualitative evaluation of soybean genotypes of European and Asian origin, cultivated in a conventional system", is structured in two parts consisting of 9 chapters that are spread over 123 pages.

The first two chapters form the "Current state of knowledge" and make a synthesis regarding: the importance and spread of soybean cultivation as well as interesting data about the zoning of this crop and the productions obtained. Also, in this part of the work, aspects regarding the requirements of soybean plants for climate and soil and its cultivation technology are presented.

The second part, "Personal contribution", consists of 7 chapters, chapter 3 presenting the purpose and objectives of the research project, followed by the presentation, in the fourth chapter, of the pedoclimatic conditions in the experimental field and their influence on the soybean crop.

Chapter five groups the data related to the experimental design, the biological material taken in the study, methods applied in the field, methods applied in the laboratory.

The most extensive chapter, Chapter 6, presents the experimental results followed by conclusions in Chapter 7. Based on the conclusions formulated, certain

recommendations were proposed in chapter 8, and chapter nine presents the elements of originality of the present study.

The PHD thesis includes 76 graphs, 19 tables and 128 bibliographic titles.

In order to evaluate from a productive and qualitative point of view a vast genetic material, of European and Asian origin, an experiment was placed at SCDA Turda in three consecutive years (2021-2023).

The main purpose is the productive and qualitative evaluation of soybean varieties included in various maturity groups, from extra early to extra late.

During the doctoral thesis, the following objectives were pursued:

- **Analysis of climate and soil conditions in the experimental field and their influence on soybean crop.**

- **Organization of a polyfactorial experiment, placed linearly, in three different consecutive years (2021, 2022, 2023) to study the behavior in terms of production and quality in 119 genotypes of European or Asian origin, from seven different maturity groups.**

- **Carrying out, during the vegetation period of the soybean crop, the notes and observations specific to this crop (date of emergence; the date of flowering; the date of the beginning of maturity; end of maturity), calculation of the vegetation period and weighing of grain production;**

- **Performing biometric measurements in the laboratory:**
  - the plant height;
  - insertion of the first basal pod
  - number of pods/plant;
  - number of grains/plant;
  - grain mass/plant;
  - TKW.

- **Determination of the main soybean quality indices for each genotype studied:**
  oil content;
  protein content;
  four fatty acids (stearic; oleic; linoleic; linolenic).

- **Study of the vegetation period, size and insertion of the first soybean pod, depending on the origin of the biological material.**

- **Study on soybean production and productivity elements, depending on the origin of the biological material.**

- **Study on the quality of soybeans, depending on the origin of the biological material.**

- **Study of the correlations between production, productivity and quality elements, depending on the origin of the biological material.**

- **Stability of production capacity depending on: material provenance, maturity group, pubescence and flower color.**
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- **Identification of genotypes with favorable agronomic properties that can be extended in culture in the area of the Transylvanian Plateau.**

- **Establishing the maturity group of each genotype, depending on the experimental results.**

During the experiment, the production and productivity elements were evaluated, and the quality of the harvest was analyzed through a non-destructive control of the grains.

In the future, the soybean research programs aim to identify and create varieties that are suitable for use in the food industry, with a larger 1000 grain mass, an open hilt and an improved chemical composition, especially by increasing the protein and oil content and with an improved fatty acid profile.

In this regard, in the experiment, in addition to production and productivity elements, the protein content, fat content and four fatty acids (one unsaturated acid - stearic acid and three saturated oleic, linoleic and linolenic acids) were determined, these being responsible for the quality and stability of the oil.

The biological material taken in the study consists of 119 genotypes of soybeans of Asian (54) or European (65) origin, from 7 different maturity groups.

The varieties of European origin come from renowned breeding centers in countries such as Serbia, France, Germany, Switzerland, Austria, Italy and Romania. The varieties of Asian origin are modern cultivations from elite centers, most of them have the shape of the leaflets lanceolate.

The study of the 119 soybean genotypes grown in the conventional system at SCDA Turda, in three different years in terms of climatic conditions, allowed the highlighting of valuable genotypes both in terms of production achieved and production stability and harvest quality. Also, the classification of genotypes in maturity groups according to their behavior in the climate and soil conditions existing in the Transylvanian Plateau, allows the extension in culture of adapted and stable varieties that will be capable of performance.

Conclusions regarding the analysis of climate and soil conditions in the experimental field and their influence on soybean crop

The three experimental years, different from a climatic point of view, allowed the highlighting of genotypes adapted to the new environmental conditions, which, based on a pronounced stability of the production capacity, can be recommended to be cultivated in the Transylvanian Plateau. In general, the three years were characterized by cold springs that influenced the emergence of soybean plants and the first part of the vegetation period, when the crop is sensitive to weeding. Then, during the vegetation period, dry months alternated with rainy ones, the rainfall being unevenly distributed. In general, the summers were characterized by high temperatures, above the multiannual average, which negatively influenced the reproductive stage of the cultivars. Out of the three years, 2022 can be considered totally unfavorable, and the highest productions were obtained in the conditions of 2021.

Conclusions on the vegetation period of the soybean crop, depending on the origin of the biological material

On average, biological material from Europe, which took 130 days to reach maturity, was almost a week earlier than Asian material (136 days). With an amplitude of maturity variation of over two months (63 days), between 99 – 158 days, European genetics includes both the earliest genotype (August variety) and the latest (ES Indicator).

Conclusions on the size of soybean plants, depending on the origin of the biological material

In the climatic conditions encountered during the experimentation period, the size of the plants was average, presented a variability with a CV = 11.72% for the European material and respectively CV = 12.62%, for the size of the genotypes from Asia.

Among the top 10 tall varieties is the early soybean variety Ada TD, created at SCDA Turda and approved in 2016.

Conclusions on the insertion of the first pod of soybean plants, depending on the origin of the biological material

The insertion of the first pod is a particularly important feature for mechanized harvesting of soybean crops, genotypes with an insertion of more than 12 cm being preferred. At SCDA Turda there were concerns about increasing the insertion height, which also emerges from the results of this experiment that positions the Miruna TD soybean variety (19.5 cm) in the top 10 genotypes for the insertion of the first pod. The

Galina variety was also noteworthy, which numbered 22.1 cm for the insertion of the first pod.

Conclusions on the number of pods/plant, depending on the origin of the biological material

The involvement of the genetic factor in the number of pods per plant is obvious, but also the influence of climatic conditions on this important quantitative characteristic. It varied greatly in genotypes from China (CV>40%). And for genotypes from Europe, the number of pods on plants experienced great variability, the coefficient of variability being in this case 28.46%.

On average, both the European and Chinese genotypes had 21 pods/plant.

For this important parameter, the European varieties stood out with a number of more than 30 pods per plant: Amma, Triada, Regina, Augusta, Ns Kaća, Gk Spirit, Miruna TD. Among the genotypes from China, the number of pods/plant exceeded 40 in three of them: Beidou 30, Fengshou 22 and Kenfeng 17.

Conclusions on the number of grains/plant, depending on the origin of the biological material

Along with the other components of production, the number of grains/plant is also influenced by the genotype and environmental conditions, respectively by the interaction between them. On average, the top 10 Asian genotypes had higher values for this important quantitative characteristic, the number of grains per plant being 12 times higher compared to the values obtained for the first 10 European genotypes. The Romanian variety Miruna TD stood out for its presence in the top 10 for European genetics.

The cultivars in Europe with more than 60 berries/plant were: TriaDa, Amma, Regina, Ns Kaća, Gk Spirit, Augusta, Paco, Ns-L-201458, Miruna TD, Antonia. As for the material from China, in the top 10 cultivations for the number of grains/plant, with values above 100 we find: Beidou 30, Fengshou 22 and Kenfeng 17.

Conclusions on the mass of 1000 grains, depending on the origin of the biological material

On average, the genotypes showed similar values for berry mass/plant (approx. 7 g), regardless of origin. However, if for 35% of the European genotypes a grain mass of more than 7 g/plant was obtained, the Asian material had higher values for this parameter, in 31 % of the cultivation a grain mass of more than 8 g/plant was obtained.

The cultivars in Europe with values above 12 g for the mass of grains/plant were: Amma, ES Gladiator, Paco. As for the genotypes from China, the following stand out: Beidou 30 and Kenfeng 17.

Conclusions on soybean crop production, depending on the origin of the biological material

On average, during the experimentation period, with a production increase of over 200 kg/ha, soybeans of European origin performed better compared to Asian soybeans. The cultivars in Europe with the highest production capacity were: ES Gladiator (4647 kg/ha), NS Kaća (4367 kg/ha), and PACO (4085 kg/ha). In the top 10 most productive varieties in China we find: Beidou 30 (4445 kg/ha) and Kenfeng 17 (4105 kg/ha). The classification of genotypes according to production performance showed that the production of the first 10 cultivations from Europe was higher than 3 t/ha.

Conclusions on protein content, depending on the origin of the biological material

The need to supplement the amount of vegetable protein by identifying valuable soybean varieties from this point of view is a problem of general interest in the context of the accelerated growth of the world's population. Based on the results obtained, genotypes such as Fengshou 22 (47.33%) and NS Kaća (45.37%) were identified, whose values for this parameter place them in the top 10 for both Asian and European genotypes. In general, a better quality of the grains in terms of protein was identified in the material from Asia.

Conclusions on oil content, depending on the origin of the biological material

Like the protein content, soybean seed oil is a valuable natural resource that could be exploited by cultivating varieties that manage to assimilate significant amounts of fat into the grain through the genetics they possess. The limits of variation were 18.9 and 24.81 for European material, respectively 17.9-24.55% for Asian material.

The cultivars with an oil content of over 24% were: NS Hogar (24.81%), Dongnong 54 (24.55%) and Heinong 64 (24.15%).

Conclusions on fatty acids in soybean oil, depending on the origin of the biological material

The fatty acid profile varied depending on the origin of the material, being noted for the stability of the oil, the varieties: Ancona (5.53%), Galician (5.40%), Heihe 39 (5.60%), Dengke 5 (5.50%), whose stearic acid content was higher than 5.30%. In terms of unsaturated fatty acids, which are known to improve the nutritional value of the oil, the following were noted:

for oleic acid: ES Gladiator (28.33%), Proteix (27.53%), Felix (26.83%), Fengshou 25 (28.43%), Heihe 36 (27.97%), Dengke 1 (27.37%);
for linoleic acid: Cristina TD (55.70%), Orion (59.50%) and Dongnong 50 (57.60%);
for linolenic acid: NS Atlas (10.70), Henong 60, Cristina TD (8.33%).

Conclusions on the study of the correlations between production, productivity and quality elements, depending on the origin of the biological material

Based on the matrix of correlations, positive links between grain production and: grain mass/plant (r = 0.76), number of grains/chain (r = 0.65) and number of pods/plant (r = 0.63) was identified for the European material. Regarding the analysis of the Pearson coefficients for the production and productivity elements of the material of asomatic origin, it is observed the existence of closer links between the production and the mass of the grains/plant, the number of grains/plant and the number of pods/plant, the calculated coefficients being higher than 0.8.

The data obtained allow the identification of genotypes that stood out for superior agronomic properties and that could be recommended for expansion in culture. The ES Gladiator variety stands out for the production obtained and for the size of the grains, having high values also for the mass of the grains/plant.

Regarding the analysis of the main components and clusters made for the material of Asian origin, the Beidou 30 variety stands out, which occupies an independent position, but also Kenfeng 17, both being characterized by high productions. Beidou 30 also has the highest values for the number of pods/plant, the number of pods/plant, and the mass of berries/plant.

For the correlations obtained between quality indices and production, it is observed that production correlates negatively, but weakly with protein content, while a closer link was observed between production and oleic acid (r=0.21). As the literature also states, in our case a strong negative relationship is established between the protein content and the oil content (r= -0.51). The Serbian variety NS Kaca stands out, which stands out for its high protein content.

For the Asian material, there is a closer inverse relationship between production and protein, but also between protein content and oil content (r=-0.71). The Fengshou 22 variety stood out for its high protein content.

Conclusions on the stability of production capacity according to: material provenance, maturity group, pubescence and flower colour

The stability of production capacity is essential to ensure high harvests regardless of the climate and soil conditions encountered. The results obtained reveal that the European material is more stable than the Asian one under the conditions encountered during the experimentation period. Also, in years with optimal temperatures and rainfall, early or semi-early soybean genotypes, as well as those with reddish pubescence, achieve higher yields compared to biological material of other maturity, with a different color of the hairs on the stem. Purple flower genotypes have been shown to be more productive regardless of the conditions encountered.

Conclusions on the grouping of genotypes by main agronomic characteristics

Knowing the importance of cultivating varieties with an adequate vegetation period, productive, which have a high MMB in order to have a good yield at processing in the food industry, but which also present a good quality of the grains, the grouping of the studied biological material allowed the identification of valuable genotypes such as: Heinong 64, Heihe 39, Ns Kaca, Augusta, Alexa, Ancona, Regina, Heihe 5, Pannonia Kincse, TriaDa, Ns Hogar, NS L-401156, Obelix, Paco, but also the varieties Mengdou 30 and Dongnong 50.

Conclusions on the reclassification of genotypes into maturity groups

Accurately establishing the belonging to a certain maturity group of a genotype has become very topical in the context of the climate changes we are going through. Thus, the increase in temperatures allows the cultivation in the area of a variety of material, from different maturity groups, from extra-early to late. Based on the results obtained, it can be stated that most of the studied genotypes behaved according to earlier maturity groups compared to those in which they were initially classified, adapting their vegetation period to the conditions they encountered in the cultivation area of the Transylvanian plateau.

Of the 119 genotypes analyzed, only 23 complied with the maturity group of belonging, as follows:

- Extra and very early genotypes: 3;
- Early genotypes: 2;
- Semi-early genotypes: 3
- Emitardive genotypes: 13;
- Late and very late genotypes: 2.

Recommendations

Based on the conclusions drawn during the work, interesting recommendations can be made both for the agricultural research environment and for growers.

In a year with normal growing conditions, it is recommended to cultivate genotypes with reddish pubescence, with purple flower, of early or semi-early maturity, which achieve higher yields compared to genotypes of other maturity, pubescence or flower.

In years with high temperatures and water scarcity during the growing season, as was the case in 2022, it is recommended to choose some genotypes:

- with purple flowers compared to those with white flowers;
- with gray pubescence, instead of those with reddish pubescence:
- extra and very early soybeans together with late and very late genotypes, which overcome the critical phases that coincide with the lack of water and high temperatures, achieving superior productions.

The genotypes: Heinong 64, Heihe 39, Ns Kaca, Augusta, Alexa, Ancona, Regina, Heihe 5, Pannonia, Kincse, TriaDa, Ns Hogar and NS L-401156 had a vegetation period suitable for the cultivation area of the Transylvanian Plateau and high productions, being recommended to be extended in cultivation in this region.

Regarding quality, the Paco variety stood out for the highest protein content, whose harvest can be destined for the food industry and the Dongnong 50 variety for the highest oil content, which can be successfully used in the production of biodiesel.

It is recommended to use the above-mentioned cultivars in crosses for the purpose of creating productive soybean varieties with improved seed quality.

In terms of the fatty acid profile, it is recommended to cultivate the following varieties in order to obtain a stable oil: Ancona, Galici, Heihe 39, Dengke 5. Regarding the quality of the oil, with good values for unsaturated fatty acids, the Cristina TD variety was identified, which has not only a light hilt and a large grain, but also a seed quality that makes it suitable for use in the food industry.

Originality

The originality of the doctoral thesis lies, first of all, in the vast biological material analyzed. Most of the 119 soybean genotypes experimented were cultivated for the first time in the pedoclimatic conditions of the Transylvanian Plateau.

Also, establishing the maturity group for each cultivar, depending on its behavior in the climate and soil conditions of central Romania, is a novelty element.

The chemical analyses carried out and the correlation of the results with the production results also contribute to the enrichment of knowledge related to soybean

cultivation, leading, we believe, in this way, to an extension of the areas cultivated with this species of crop plant.

The novelty element also lies in the identification of valuable crops both for the research and academic environment, as well as for soybean growers.