

Research on the Behavior of Soybean Varieties With Italian and German Genetics under Pedoclimatic Conditions of Moldova

Alexandra LEONTE^{1,*}, Simona-Florina ISTICIOAIA¹, Sabina-Andreea PINTILIE¹, Doru STANCIU¹, Paula PINTILIE¹

Agricultural Research and Development Station Secuieni, Secuieni – Neamț, 617415, Romania

**Corresponding author: andra29nt@yahoo.com*

Abstract. Testing soybean varieties is an essential step in the process of adapting the crop to the pedoclimatic conditions of each area. By evaluating their performance under various soil and climate conditions, the most resistant and productive varieties can be identified, ensuring optimal yields and more efficient resource management. This process contributes to maximizing yields and reducing risks associated with climate or soil fluctuations, supporting long-term sustainability in soybean cultivation. However, in the soybean experiments set in central Moldova, the experimental years were 2023 and 2024, yields were significantly impacted by heatwaves and drought during the flowering stage of the soybean crop, emphasizing the importance of conducting longer trials, as only two years of testing were carried out. A more extended testing period would provide a clearer understanding of how different soybean varieties perform under varying climatic conditions.

Keywords: climatic conditions, crop, quality traits, soybeans, yield.

INTRODUCTION

Soybean (*Glycine max* (L.) Merrill) is one of the oldest cultivated plants (Adamič et al, 2021; Da Silva et al, 2022), dating back over 7000 years (Neupane et al, 2022), with a very rich nutritional value, and introduced to America and Europe around 1739-1740 (Da Silva et al. 2022; Lemes et al, 2022; Wenda-Piesik and Ambroziak, 2022). It later appeared in Romania, and then appeared in Transylvania in 1876, expanding widely after 1930 (Chețan et al., 2021).

Chețan et al. (2022) says that soybean is a highly valuable crop not only for its diverse applications but also for the agronomic benefits it provides.

Soybeans are the most widely used beans in the food industry and provide economic benefits for small-scale farmers (Zerihun et al., 2015). It is one of the key food crops valued for its role as a source of vegetable protein (Kuntyastuti et al., 2019). Soybeans, abundant in oil and protein, are globally acknowledged as a valuable supplementary source of edible oil and nutrition (Kaul & Das, 1986).

Soybean is a major provider of vegetable protein for humanity and ranks among the most affordable and accessible protein sources, particularly in developing nations (Idrisa, 2010). Having been cultivated and used for almost 5,000 years, and celebrated as a “miracle” plant of the twentieth century, the soybean remains a focus of interest due to its many uses and great significance (Sin, 2000).

Interest in the impact of agriculture on soil structure or changing soil species makeup has increased. Due to its major position as one of the more important crops, more research into soybean (*Glycine max* L. (Merr)) management can contribute to optimizing yield and improving crop management (Pagano & Miransari, 2016).

Soybean is one of the most important sources of plant protein and is known for its wide range of agricultural, food, and industrial applications as well as health benefits. Interest in soybean proteins has been steadily growing as progressively more applications and benefits are discovered (Cabanos et al., 2021).

In addition to providing a variety of by-products for the manufacturing sector that are high in quantity, quality, and affordability, soybeans are a plant that provides vital nutrients for both human and animal nutrition (Nicolae et al., 1986).

Due to the diverse pedoclimatic conditions in its cultivation area, choosing the right variety based on local environmental factors is essential, necessitating a comprehensive understanding of its behavior under specific conditions (Mureșanu & Mărginean, 2011).

As noted by Gus et al. (2004), the importance of soybean as an agricultural crop derives from its multiple applications: it serves as a nutritious element in human diets (with oil, mature grains, and green pods used in a range of dishes), a key feed source for livestock, a raw material for various industrial processes (including oil for paints, plastic manufacturing, and margarine production), and a plant that improves soil physical characteristics through a symbiotic relationship between its roots and nitrogen-fixing bacteria (*Bradyrhizobium japonicum*).

The soybean crop accounts for around 28% of worldwide production of edible vegetable oil. Typical composition of soybean oil includes 12% palmitic acid, 4% stearic acid, 23% oleic acid, 53% linoleic acid, and 8% linolenic acid. Oil quality is greatly affected by the makeup and arrangement of fatty acids. Studies indicate that temperature has a substantial impact on the levels of fatty acids, especially unsaturated types like oleic acid, which is particularly reactive to changes in the environment. Furthermore, a significant inverse correlation has been found between yield and oleic acid content. According to Kim (2015), lines with elevated oleic acid levels

can provide a genetic basis for developing varieties that diversify food applications and produce high-quality oil akin to olive oil. Currently, soybean breeding objectives focus on developing varieties intended for human consumption, characterized by high yields, early maturity, enhanced resistance to diseases and pests, and superior agronomic traits compared to existing cultivars (Gaynor et al., 2011).

Due to the significance of the species, A.R.D.S. Secuieni conducted studies on the behavior of nine soybean varieties under varying environmental conditions during the 2023 and 2024 timeframe. Among the nine tested varieties, four are based on Italian genetics and five on German genetics. The findings generated during the research and their interpretation are presented in this scientific paper.

MATERIAL AND METHODS

The research was conducted during 2023 and 2024, in the experimental field from A.R.D.S. Secuieni (Agricultural Research and Development Station Secuieni) and its objective was to assess the adaptability of nine soybean varieties, belonging to four different maturity groups (Table 1).

Table 1. The biological materials used in the experiment, their origin, and the maturity group

No.	Variety	Maturity group	Origin	No.	Variety	Maturity group	Origin
1	Smaragd	0	Germany	6	Diamante	0	Italy
2	Dakota	00		7	Avatar	I	
3	Yakari	000		8	Namaste	I	
4	Chiaki	0		9	Nirvana	I	
5	Annika	I					

000 = very early; 00 = early; 0 = medium-early; I = medium-late

The field experiment was placed on a typical cambic chernozem soil type, middle texture, acid: pH_{H2O} – 5.98, characterized as: supplied in phosphorus (77.6 ppm PAL), Ca (13.6 mEq/100 g soil Ca) and Mg (1.8 mEq/100 g soil Mg), middle supplied in active humus (1.88%) and nitrogen (16.2 ppm N-NO₃) and poorly supplied in potassium (124.6 ppm K₂O) (Pochișcanu et al., 2017). The experiment was arranged using the Latin rectangle method, with three replications, each soybean variety occupying a total area of 30 m². This method allowed for a rigorous evaluation of the differences between varieties, ensuring effective control of environmental variability.

The analysis of temperature and precipitation throughout the soybean growing season in the Secuieni area reveals a shift toward hotter and drier conditions. These extreme weather conditions could lead to substantial agricultural losses. The deviations observed in the temperature data underscore a significant temperature increase compared to the multiannual averages of the same period. This increase is particularly evident in the warmer months, namely July and August, where the temperatures are markedly higher than the 60-year averages. The temperatures for these months have exceeded the multiannual averages by 3.2°C and 3.9°C, respectively. This stark deviation signals a clear trend towards hotter conditions, which is particularly concerning for agricultural practices (Figure 1). This warming trend is significant for agriculture, especially for crops like soybeans that are highly sensitive to temperature variations. Soybeans, in particular, require specific temperature ranges for optimal growth and yield.

The crop technology specific to the conditions in Central Moldavia was used in this case, and the data obtained was processed and interpreted statistically according to variance analysis (Leonte and Simioniuc, 2018).

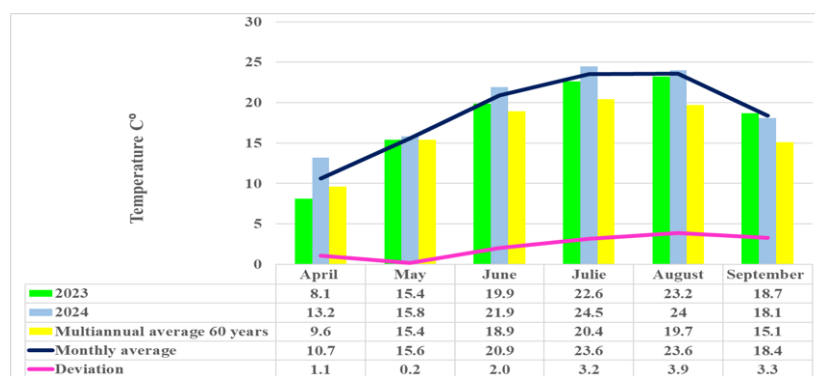


Figure 1. Average temperature (°C) during the soybeans vegetation period, A.R.D.S. Secuieni, 2023 and 2024

The year 2023 had precipitation levels closer to the multiannual average in most months, but still recorded a deficit in April, May, and September. During the summer months of June and July 2023, the amount

of precipitation was higher than in 2024, indicating a more balanced distribution of rainfall throughout the summer (Figure 2). Overall, 2023 was a less extreme year in terms of precipitation, without major deviations like those in 2024, when the summer drought was followed by a sudden excess in September. In the spring and summer of 2024, a significant precipitation deficit was recorded, particularly in May, June, and July, compared to the multiannual average. The drought during the warm months can negatively impact agriculture and water resources, exacerbating the risks associated with climate change. Comparing the two years, it can be observed that 2023 had a more balanced rainfall regime, while 2024 was characterized by drought during the summer months and excessive precipitation in September.

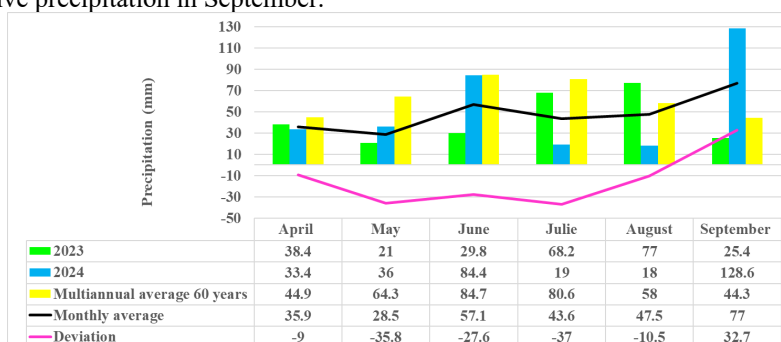


Figure 2. Precipitation (mm) during the soybeans vegetation period, A.R.D.S. Secuieni, 2023 and 2024

RESULTS AND DISCUSSIONS

Throughout the soybean growing season, a series of assessments were carried out to characterize the studied varieties. The height of the plants for the varieties studied varied significantly, with values ranging from 54.1 cm (Dakota) to 70.4 cm (Chiaki), and the 16.3 cm difference between the extremes reflects the direct influence of genetic characteristics and environmental conditions on growth (Figure 3).

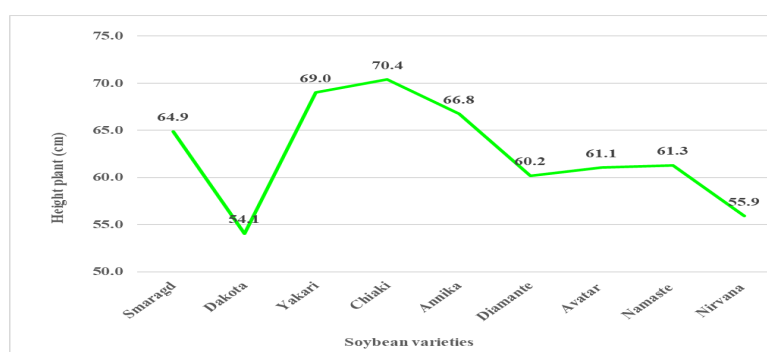


Figure 3. The average height (cm) of soybean plant

The varieties Nirvana (48.1 pods/plant), Avatar (46.9 pods/plant), and Namaste (39.5 pods/plant) exhibited the highest number of pods per plant. The varieties Diamante (37.1 grains/plant), Avatar (27.2 grains/plant), and Chiaki (24.2 grains/plant) recorded the highest number of seeds per plant among the nine soybean varieties analyzed (Figure 4). Varieties such as Diamante and Avatar are highly productive in terms of grains, while Nirvana and Avatar achieved the highest number of pods per plant. The Avatar soybean variety stood out with the highest number of pods per plant, as well as the highest number of seeds per plant.



Figure 4. The number of pods and grains on the plant on the soybean varieties

The Diamante variety recorded the highest seed weight per plant, reaching 7.0 grams, significantly surpassing the other varieties, while the Yakari variety had the lowest weight, with 2.8 grams per plant (Figure 5).

The hectoliter weight values of the studied soybean varieties are relatively close, ranging from 66.2 kg hl⁻¹ (Nirvana) to 72.1 kg hl⁻¹ (Yakari). Most of the varieties have a density between 68 and 71 kg hl⁻¹, highlighting a general consistency in the structure and composition of the seeds. Regarding the thousand kernel weight, there is a considerable variation among the analyzed varieties, with a difference of over 50 g between the lowest value, Chiaki (133.8 grams), and the highest, Diamante (184.0 grams). Most of the varieties have a weight ranging between 140 and 170 grams (Figure 6).

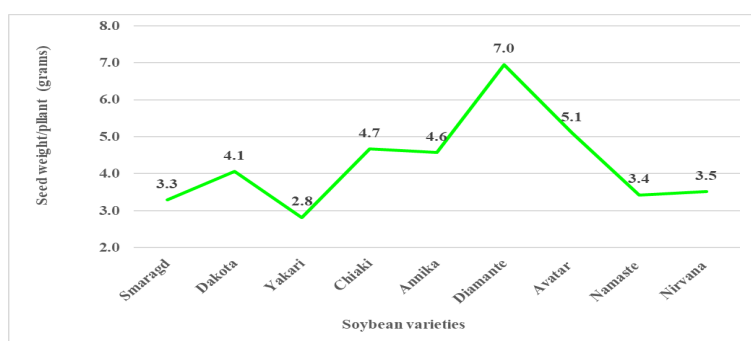


Figure 5. Seed weight (grams) per plant at soybeans

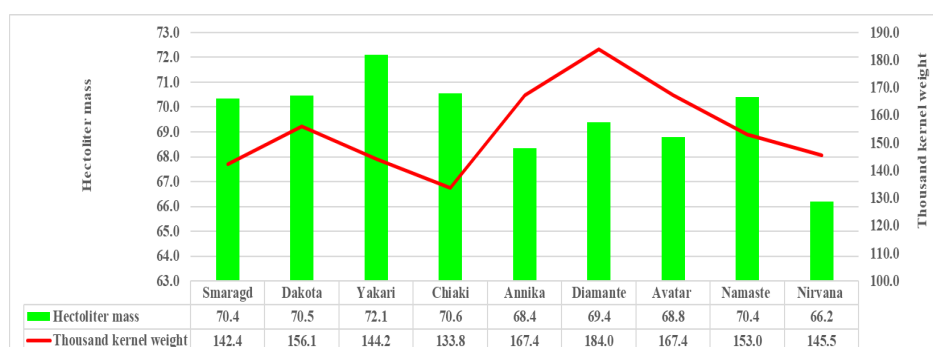


Figure 6. Thousand kernel weight (grams) and hectoliter mass (kg hl⁻¹) at soybeans varieties

The atmospheric heatwaves and drought that occurred at the end of June and the beginning of July had a significant impact on the development of the soybean crop, causing partial flower abortion. These extreme climatic conditions negatively affected the pollination and fertilization processes of the plants, thereby impacting the yields. The soybean variety Smaragd was chosen as the control in the experiment because it has been consistently tested and studied for several years in the experimental fields of A.R.D.S. Secuieni.

The experimental results obtained during the analyzed period reveal significant differences in the yields of the studied soybean varieties. Average yields varied widely, ranging from 433 kg ha⁻¹ for the Smaragd variety to 818 kg ha⁻¹ for the Chiaki variety. Of the nine soybean varieties studied, four of them (Chiaki, Annika, Avatar, Namaste) recorded higher yields than the control variety (Smaragd), and these differences were statistically significant and interpreted as highly significant. The other four varieties (Dakota, Yakari, Diamante, Nirvana) recorded yields that were statistically significant but distinct.

The analysis of relative yields shows that most soybean varieties exceeded the control variety, Smaragd. The highest relative yield values were obtained by the Chiaki (89%), Avatar (50%), and Namaste (51%) varieties. These varieties stand out for their significant productivity and represent excellent options for farmers focused on maximizing yields. Varieties such as Dakota (31%), Yakari (33%), and Diamante (31%) recorded more modest, yet still significantly higher, yields than Smaragd, with an increase of about 30-40% compared to it. In contrast, the Nirvana (30%) and Annika (41%) varieties recorded relative yields between 30% and 41% (Table 2).

Table 2. Yield recorded for soybean varieties under pedoclimatic conditions from A.R.D.S. Secuieni

Variety	Yield (kg ha ⁻¹)	Relative yield (%)	Difference from control (kg ha ⁻¹)	Significance
Smaragd	433	100	Control	-
Dakota	568	131	135	**

Yakari	577	133	144	**
Chiaki	818	189	385	***
Annika	611	141	178	***
Diamante	565	131	132	**
Avatar	650	150	217	***
Namaste	652	151	219	***
Nirvana	563	130	130	**
LD kg ha ⁻¹ 5% = 76; 1% = 105; 0,1% = 144				

Regarding protein content, the varieties Yakari (47.2%) and Nirvana (47.1%) stand out with the highest values. The Diamante variety (46.1%) is also among the richest in protein, while the Chiaki variety (43.9%) recorded the lowest protein content among the analyzed varieties.

For the varieties studied, the oil content was high, with varieties like Namaste (20.9%), Chiaki (20.7%), and Annika (20.5%) showing notable values. However, the Yakari variety (18.5%) recorded the lowest oil content. The Smaragd variety, used as a control in this analysis, shows intermediate values for both parameters: 45.6% protein and 19.7% oil (Figure 7).

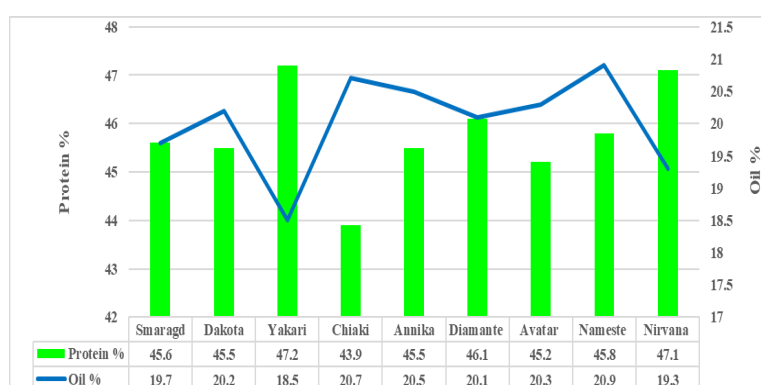


Figure 7. The protein (%) and oil (%) content in the studied varieties

CONCLUSIONS

Over the two years of experimentation, the average yield of the nine soybean varieties tested at A.R.D.S. Secuieni showed considerable variation, ranging from 433 kg ha⁻¹ (Smaragd) to 818 kg ha⁻¹ (Chiaki). However, the yields were influenced by atmospheric heatwaves and the drought that occurred during the flowering phase of the crop.

The hectoliter weight of the studied soybean varieties varies slightly, ranging from 66.2 kg/hl in the Nirvana variety to 72.1 kg/hl in the Yakari variety. Meanwhile, the thousand kernel weight shows a more pronounced variation, with a difference of over 50 grams between the minimum value of 133.8 grams (Chiaki) and the maximum value of 184.0 grams (Diamante).

The growing temperature, along with changing precipitation, suggests an urgent need to adapt agricultural practices to these evolving climate conditions. For farmers, this may involve adopting drought-resistant crop varieties, adjusting planting and harvest schedules, or investing in irrigation systems to mitigate the effects of reduced rainfall. Moreover, it is necessary to revise the growing dangers brought about by climate change, with an emphasis on sustainability, conservation of water resources, and farming methods that can withstand climate impacts.

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