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SOYBEAN CROP DEVELOPMENT, YIELD AND HARVEST QUALITY UNDER TWO SOWING DATE

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Abstract

The influence of the sowing date, genotype and climatic conditions on the soybean crop development, yield and seed quality, was studied in a field experiment placed at Research and Development Station for Agriculture (RDSA) Turda, in three consecutive years. The ten soybean genotypes were sown in: 2021, 2022 and respectively 2023, in the experimental field of the Soybean Breeding Laboratory. The biological material consisted of very early (Perla, T12-295), early (Onix, Felix, Cristina TD, Caro TD, T14-4203) or semi-early (Raluca TD, T26-6126, Avatar) genotypes. Based on the experimental results, a decrease in yield was obtained when late genotypes were sown in the second date. For early soybean biological material, the results for production were similar in both sowing dates. In terms of quality, delayed sowing date contributed to an increase in protein content from 35.70% to 36.26%, while the oil content decreased by 0.40% by practicing late sowing.

Key words: *soybean, quality, sowing date, yield.*

INTRODUCTION

Soybean (*Glycine max* [L.] Merr.) is one of the most important food crops (Negrea et al., 2023) but also the most widespread leguminous crop worldwide (Ren et al., 2023), due to the wide range of use of its seeds in many branches of the food and technical industry (Guzeler & Yildirim, 2016; Suciu et al., 2022).

With a seed content of about 40% protein and about 20% fat (Staniak et al., 2021), soybeans are used in many countries predominantly in human food and the other parts are used in animal feed. This crop is also a source of many important compounds such as fibre, lecithin, vitamins and mineral salts (Bellaloui et al., 2015).

As one of the cheapest sources of protein, soybean plays an important role in the diet of people in developing countries, where human beings face protein deficiencies (Chaudhry, 1985).

Climate change can have negative effects on temperate zone agriculture due to scarcity of water available to plants in summer, as well as increasing decline in water resources available in soil throughout the growing season (Falloon & Betts, 2010; Kasperska-Wołowicz et al., 2021).

These climatic stress conditions in the soybean reproductive stage can reduce seed yield even by 74% (Jumrani & Bhatia, 2018) if measures are not taken to reduce adverse conditions.

The quality and quantity of soybean harvest may be affected by the genetic potential of the variety, environmental conditions during the growing season and applied cultivation technology (Ionescu et al., 2016; Yilmaz, 2003). Stressors can disrupt plant metabolic processes, cause damage to cell structure, inhibit plant growth and development, and cause seed production and quality to decline and deteriorate (Hou et al., 2006; Michałek & Borowski, 2006).

The growth and development of soybean plants are strongly influenced, besides climatic conditions and sowing time (Albrecht et al., 2008) but also by applied technology.

Research carried out so far has shown that sowing soybeans too early could lead to slow emergence and growth in the early stages of development, but drought stress could be avoided during critical periods, when rainfalls are very low and high temperatures persist for several days, and that delayed sowing leads to significant decreases in production, these are most often associated with reductions in both vegetative and reproductive periods (Bateman et al., 2020).

In the context in which the climate is constantly warming and plants need to adapt to climate change, identifying the factors that influence the formation of crop production, especially climatic ones, is of great importance.

The purpose of this study was to determine the influence of climatic conditions and sowing date on soybean yield and quality, but also on the number of days from sowing to the most important vegetation stages, for soybeans grown in pedo-climatic conditions in the Transylvanian Plateau.

MATERIALS AND METHODS

The purpose of this study consisted in evaluation of ten soybean genotypes in terms of crop development harvest and quality as influenced by:

- technological factors sowing date;
- genotype;
- climatic conditions.

To achieve these goals, an experiment was accomplished at the field of Research and Development Station for Agriculture (RDSA) Turda, in three different under climatic factors, but consecutive years.

The experiment had three replications and was based on the method of subdivided plots. Each plot had an area of 10 m^2. The soybean genetics studied consisted of very early, early or semi-early genotypes that were sown in the experimental field of the Soybean Breeding Laboratory in: 2021, 2022 and respectively 2023. In each of the three experimental years, the delaying sowing date influence on soybean crop yield and quality was studied, sowing being carried out, depending on the climatic conditions of each year, on:

- Year 2021: April 12 and May 5, respectively;
- Year 2022: April 6 and May 3, respectively;
- Year 2023: April 21 and May 2, respectively.

During the growing season, observation and notations of soybean crop development in terms of the main phases were made according to American Code (FEHR and CAVINESS, 1977). Thus, during the paper are presented data on the difference in the number of days from sowing to: beginning of flowering (R1), beginning of maturity (R7), respectively end of maturity (R8) for each of the 10 soybean studied cultivars and three years, between the two sowing dates. Also, at maturity, the experimental variants were harvested and weighed, the yield obtained on each plot being reported per ha.

The seeds of each experimental variant were analysed in the laboratory using near-infrared spectrophotometry to determine the main soy quality indices (protein, fat, stearic acid, oleic acid, linoleic acid and linolenic acid).

The data obtained were statistically processed using ANOVA, and the graphical exemplification of the results was performed with Microsoft Excel.

RESULTS AND DISCUSSIONS

RDSA Turda is located in the north-western part of Turda, the climate of the area, according to the Köppen classification, is rendered by the D.f.b.x. formula, which defines the boreal climate with continental influences, with four distinct seasons. The meteorological data were recorded at Turda Meteorological Station, at an altitude of 427 m and having the following geographical coordinates: longitude 23°47’ and latitude 46°35’. The climatic conditions in the three experimental years varied in terms of temperatures and rainfall, which was reflected in the growth and development of soybean plants and in the level of grain yields obtained from one year to another (Figure 1).

The three experimental years were very different in terms of thermal and pluviometric regime. In general, the first two months of spring were characterized by lower temperatures and rainfall compared to the multiannual average, which led to a late emergence of soybean plants when the first sowing date was experienced (the date of emergence being noted about three weeks after sowing). Also, plant emergence was uneven in the third year of study. In the three experimental years, the rainfall and high temperatures registered in May, led to a uniform emergence of soybean plants sown in the second date (2 weeks, one week, respectively 3 weeks after sowing). The data presented by Dima (2006) are similar to those recorded in our experiment regarding the number of days from sowing to emergence, namely that for the first time of sowing the period between sowing and emergence is longer than for the second date of sowing.

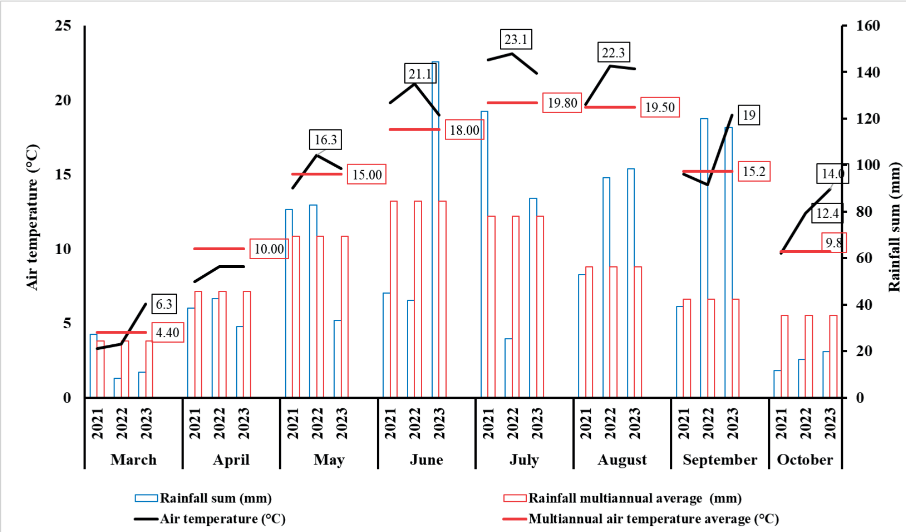

Figure 1. Mean air temperature and rainfall of each month during soybean growing season (Turda, 2021-2023)

On average, the date of flowering (R1) was 6 days shorter when late sowing was practiced and was noted approximatively at the same calendar date, regardless of the sowing time or experimental year (Figure 2).

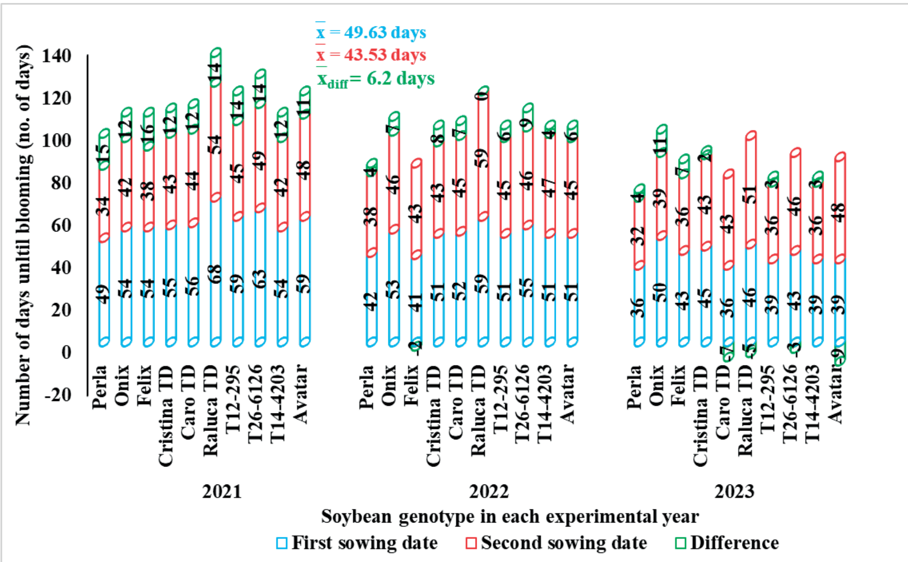

Figure 2. Number of days until blooming (R1) for each soybean genotype and sowing date experimented (Turda, 2021-2023)

The obtained data reveals a variable length of vegetative period of each genotype, the generative stage starting at different time, in each experimental year and sowing date.

In 2023, Perla, the very early variety of soybean created by RDSA Turda, reached flowering 32 days after emergence when it was sown on the second date.

As expected, the beginning of flowering for Raluca TD semi-early soybean variety was noted on July 5, 68 days after emergence, when it was sown on April 12.

On average, when delayed sowing was practiced, the stage of beginning maturity (R7) for soybean biological material was reached 8 days earlier compared to the first sowing date (Figure 3).

If in the first experimental year the period required to reach the vegetation phase R7 was much lower for genotypes sown late compared to the first sowing date, the opposite happens in the last experimental year. If the very early soybean variety Perla had the shortest period from sowing to early maturity, the Raluca TD variety and the T26-6126 line, reached the R7 vegetation phase in a greater number of days.

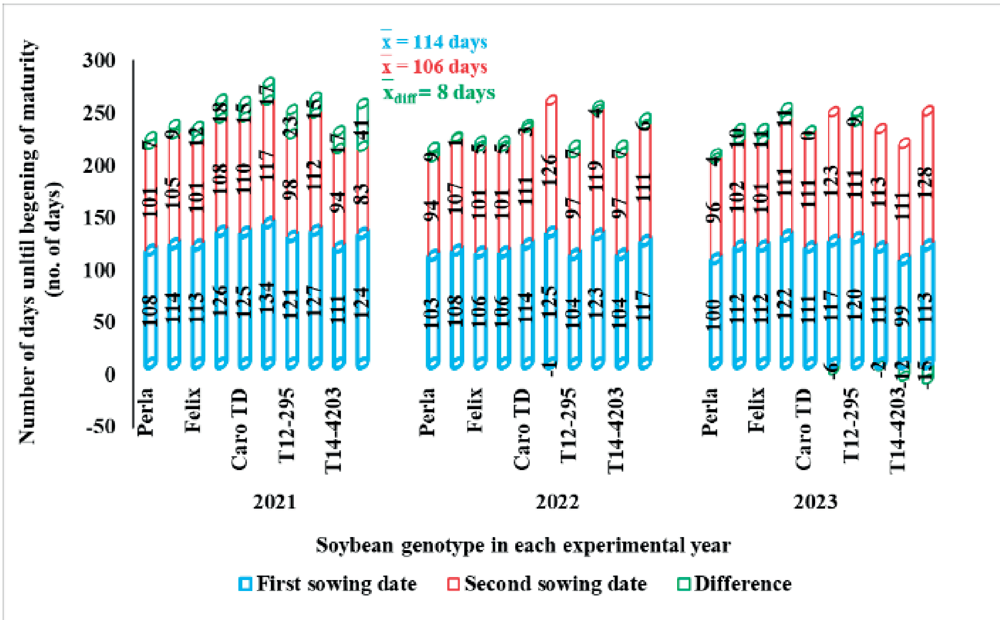

Figure 3. Number of days until beginning of maturity (R7) for each soybean genotype and sowing date experimented (Turda, 2021-2023)

In a study conducted by Serafin-Andrzejewska (2021), when 20 days of delayed sowing date was experimented in relation to the early date, a shortening of the growing period by 14 days was observed. Research by Księżak & Bojarszczuk (2022) showed that the 20-day delay in the sowing date resulted in shortening the growing season by 18 days, compared to soybeans sown at the optimal time, indicating that the growing season remains the same in number of days, even if sowing is done earlier.

In our experiment, by practicing the second sowing date, the growing season of the ten soybean varieties was 6 days shorter (Figure 4). The ten soybean cultivars experimented are characterized by different maturity, therefore, differences in their development were observed. As expected, for: T26-6126 line, Raluca TD and Avatar semi-early soybean genotypes a longer period of vegetation was identified in all three experimental years and two sowing dates.

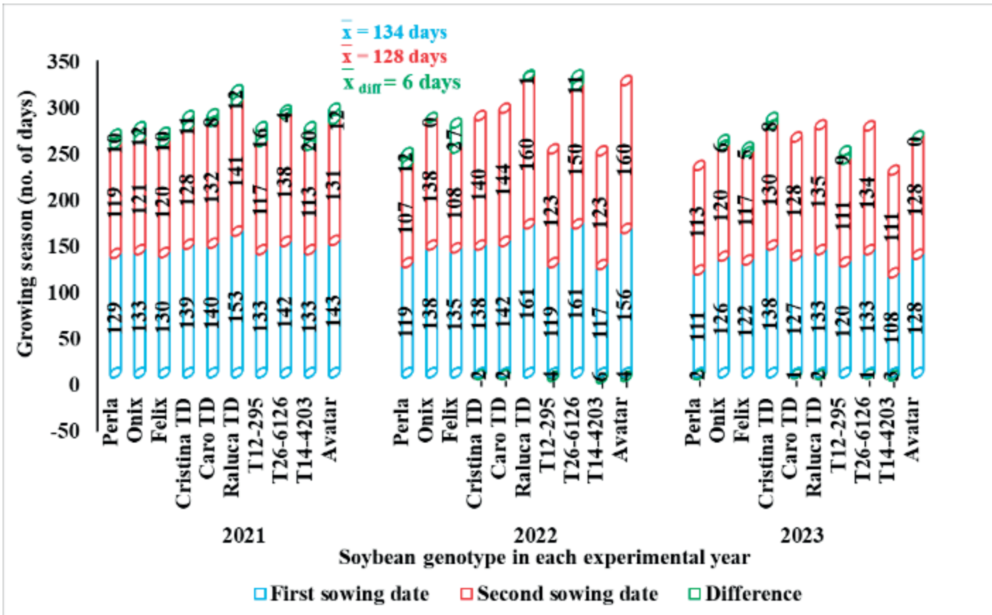

Figure 4. Number of days until the end of maturity (R8) for each soybean genotype and sowing date experimented (Turda, 2021-2023)

From the table with analysis of variance (ANOVA) it can be seen that grain yield and seed quality were greatly influenced by the three factors studied (Table 1).

In 2022, with very significantly negative differences compared to the average of years, the lowest values were obtained for: grain yield (1424 kg/ha), fat content (18.61%), oleic acid (23.35%) and linoleic acid (52.77%). In 2023, the highest grain yield of 3540 kg/ha was achieved. Also, in the same experimental year, the highest values of protein content were identified (38%), soybeans being also the oiliest (22.83%), similar results were obtained in a study by Popa et al. (2023). The research carried out by Şimon et al. (2023) shows the important contribution of the time of sowing the crop in the increase of soybean yield.

Regarding the sowing date factor, the practice of late sowing date resulted in a decrease of approximately 100 kg/ha in the grain yield. Also, the quality of the seeds was influenced by the sowing date. While there was an increase in protein content from 35.70% to 36.26%, these results are in line with those reported by Khan et al. (2001) which stated that the percentage of protein in soybeans sown later was higher than in soybeans sown earlier. The oil content decreased by 0.40% by practicing late sowing.

The highest seed yield was observed in semi early soybean genotypes (3540 kg/ha) followed by early soybean cultivars (2570 kg/ha) and very early soybean genotypes (2416 kg/ha). As stated by Suciu et al. (2020), yield and yield elements vary by maturity group and genotype.

In terms of quality, the chemical composition of seeds varied between the three maturity groups studied. Generally, for late genotypes, a decrease in quality was observed compared to the early soybean cultivars.

The results obtained by Kane et al. (1997) showed that delayed seeding of soybeans led to an increase in the percentage of protein and linolenic acid, but also to a decrease in the percentage of fat and oleic acid, while the linoleic acid content was not affected.

Table 1. ANOVA test for yield, yield elements and main quality parameters in ten soybean genotypes sown at two different dates

FACTOR		Yield (kg ha^{-1})	Protein content (%)	Fat content (%)	Stearic acid (%)	Oleic acid (%)	Linoleic acid (%)	Linolenic acid (%)
YEAR (Y)	2021	2821***	33.39^{000}	19.56^{000}	4.84**	23.55^{00}	55.17***	6.60^{ns}
	2022	1424^{000}	36.56***	18.61^{000}	5.00***	23.35^{000}	52.77^{000}	6.58^{ns}
	2023	3540***	38.00***	22.83***	4.42^{000}	24.70***	54.57*	6.04^{00}
	Average-Control	2595^{Ct}	35.98^{Ct}	20.33^{Ct}	4.75^{Ct}	23.87^{Ct}	54.17^{Ct}	6.41^{Ct}
SOWING DATE (S)	First sowing date (Control)	2639^{Ct}	35.70^{Ct}	20.52^{Ct}	4.88^{Ct}	23.75^{Ct}	54.35^{Ct}	6.23^{Ct}
	Late sowing date	2550^{00}	36.26***	20.15^{000}	4.62^{000}	23.99***	53.99^{00}	6.58***
SOYBEAN MATURITY GROUP (M)	Very early genotypes (000)	2416^{00}	36.94***	20.67^{ns}	4.88**	24.14^{ns}	53.82^{ns}	6.84***
	Early genotyeps (00)- Control	2507^{Ct}	35.89^{Ct}	20.50^{Ct}	4.83^{Ct}	23.99^{Ct}	53.94^{Ct}	6.07^{Ct}
	Semi-early genotypes (0)	3540***	35.11^{000}	19.83^{00}	4.54^{000}	23.47^{000}	54.75***	6.31*
ANOVA	Y			***	***	***	*** *** ***	***
		S					*** *** *** *** *** **	***
		M					*** *** *** *** *** ***	***

In other studies, different seed yield for late season and short season genotypes was obtained when delayed sowing was practiced (Chen et al., 2010; Salmerón et al., 2015; Vossenkemper et al., 2016).

Based on our experimental results, by analysing the interaction of sowing date and maturity group (Figure 5), it can be stated that the highest yield was obtained in the first sowing date. For late genotypes (MG 0), a decrease in yield, statistically assured as very significant (2755 kg/ha) was obtained when second date of sowing was analysed compared to the first sowing date (2968 kg/ha).

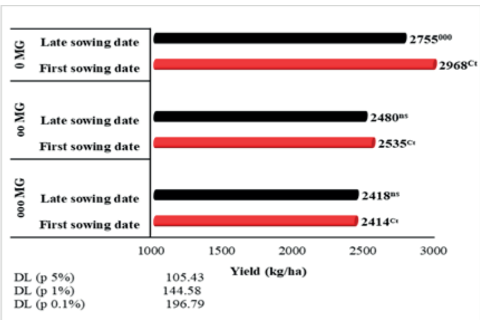

Figure 5. Interaction of sowing date and maturity group on soybean yield (Turda, 2021-2023)

Based on chemometric analysis obtained for yield and quality of ten soybean genotypes, sown at the recommended time, a high value for protein content in T12-295 perspective line and high yield in Avatar genotype are highlighted (Figure 6).

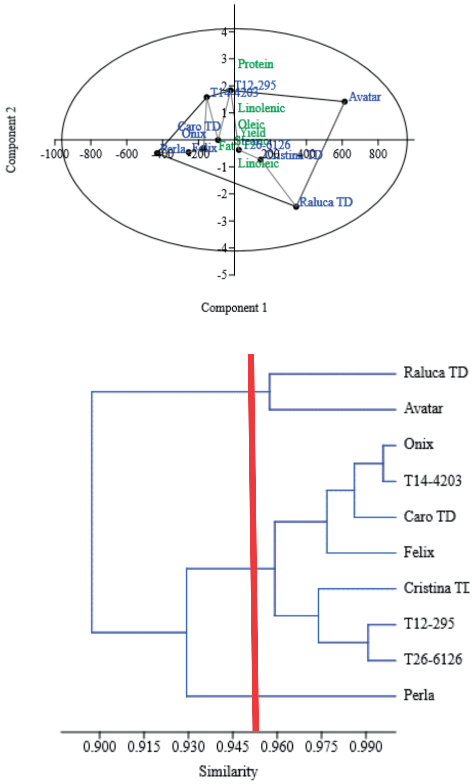

Figure 6. PCA and hierarchical clustering based on yield and quality in ten soybean genotypes obtained in the first sowing date

In terms of hierarchical clustering, while Perla variety presented an independent position related with maximum value obtained for fat content and minimum value for yield, 2 different clusters are observed. First cluster groups Avatar and Raluca TD varieties, with high yield and minimum values for almost all quality parameters. The second one consist in seven soybean genotypes with medium values obtained for studied traits.

When chemometric analyses was processed for second sowing date (Figure 7), high protein was related with T12-295 and T14-4203, while high yield was obtained in three genotypes: Avatar, Raluca TD and Caro TD.

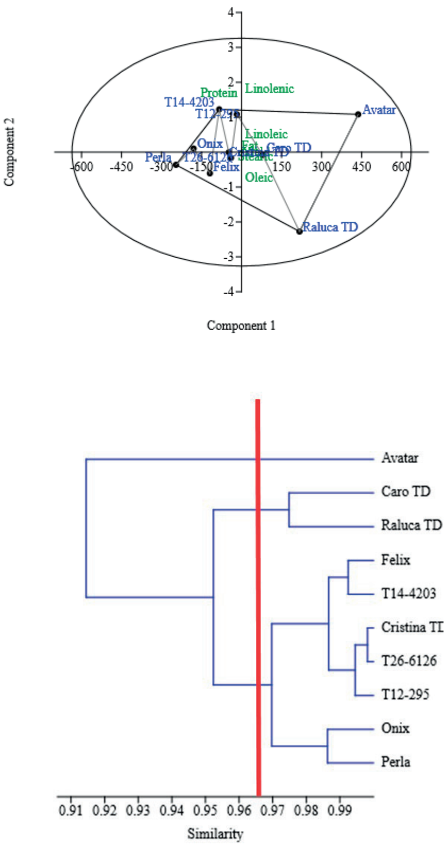

Figure 7. PCA and hierarchical clustering based on yield and quality in ten soybean genotypes obtained in second date

In this experimental variant, four different clusters are identified, while Avatar variety occupies an independent position based on obtained results. First cluster consist in Caro TD and Raluca TD varieties, with similar values obtained for yield, protein content, oleic and linoleic content. Second cluster groups Felix variety and T14-4203 line, with appropriate yield, protein content and oleic content. Cristina TD, T12-295 and T26-6126 form the third cluster with medium values for all studied parameters. With the smallest yield, highest fat content and stearic acid combined with good result for protein content, Onix and Perla varieties are grouped in the fourth cluster.

CONCLUSIONS

The period from emergence to the beginning of flowering stage (R1) was shortened by six days when delayed sowing date was experimented compared to the earliest sowing date.

The same trend was observed for the number of days from emergence to beginning of maturity (R7) and until the end of maturity (R8), respectively.

The most favourable for high soybean yield (2639 kg/ha) was the first sowing date.

In terms of quality, delayed sowing date contributed to an increase in protein content from 35.70% to 36.26%, while the oil content decreased by 0.40% when late sowing was practiced.

Fatty acid profile was different depending on sowing date, higher results for oleic and linolenic acid being obtained when late sowing was experimented.

Based on the experimental results, a decrease in yield was obtained when late genotypes were sown in the second date. For early soybean biological material, the results for production were similar in both sowing dates.

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