International Journal of Sustainable Agricultural Research
2023 Vol. 10, No. 4, pp. 102-108
ISSN(e): 2312-6477
ISSN(p): 2313-0393
DOI: 10.18488/ijsar.v10i4.3573

Influence of sowing season on some quality indices for soybean

Alin Popa[1]
Alina Simon[2]
Adrian Ceclan[3+]
Raluca Rezi[4]
Camelia Urda[5]
Marius Bardas[6]
Felicia Chetan[7]

[1,2,3,4,5,6,7] *Agricultural Research and Development Station Turda, 27 Agriculturii Street, Turda, 401100, Romania.*
[1]*Email: alin_popa1992@yahoo.com*
[2]*Email: alina.simon@scdaturda.ro*
[3]*Email: adi.ceclan@gmail.com*
[4]*Email: raluca.rezi@scdaturda.ro*
[5]*Email: cami1586@yahoo.com*
[6]*Email: marius.bardas@yahoo.com*
[7]*Email: felice_fely@yahoo.com*


(+ Corresponding author)

Article History
Received: 17 October 2023
Revised: 27 November 2023
Accepted: 12 December 2023
Published: 29 December 2023

Keywords
Fat content
Protein
Sowing season
Soybean
Yield.

ABSTRACT

Soybean quality indices, like yield, can be influenced by factors such as climatic conditions, applied technology or biological material. Soybean is a short-day species with moderate temperature requirements, especially during flowering, a critical period for achieving yield and crop quality, air temperature in the range of 17-18°C is considered the biological minimum, while the range of 22-25°C is considered optimal. High temperatures during the flowering period can cause significant yield losses through flower abortion especially when correlated with insufficient humidity. This paper presents summary data obtained in soybean cultivation under the conditions of the Transylvanian Plateau at Agricultural Research and Development Turda on the influence of sowing time on some quality indices. The experiment was realized using the block method in subdivided plots with 3 factors AxBxC on a type soil chernozem, characteristic of the Transylvanian Plateau with chemical description, the soil has a neutral to low alkaline pH, neutral to high humus content, well supplied in nitrogen and potassium, medium supplied in phosphorus. During three experimental years 2021 - 2023 climatic conditions and sowing times influenced differently the protein and fat content of 5 soybean varieties. The results obtained were statistically processed by the analysis of variance method and determination of the least significant difference - LSD - (5%, 1% and 0.1%).

Contribution/Originality: Soybean is a plant that occupies important areas. Therefore, the challenge of this study is to conduct an experience to evaluate the behavior of soybean cultivation in agro-climatic conditions in the ARDS Turda region, which is the representative area of the Transylvanian Plateau. The research has resulted in the presentation of quality results for 5 soybean varieties created at ARDS Turda during the sowing period for 3 years.

1. INTRODUCTION

The importance and wide variety of uses of soybean, which has been cultivated and used for almost 5,000 years, continue to attract attention today (Sin, 2000).

Soybean (*Glicine max* L. Merrill) is the world's main source of protein and oil (Fekadu, Hussein, & Getinet, 2009), used in the food and feed industry (Yilmaz, 2003), with 85% of its production going to animal feed and the

rest to human consumption (Thrane, Paulsen, Orcutt, & Krieger, 2017). The protein content of soybeans is around 40% and the oil content is 20% (Medic, Atkinson, & Hurburgh, 2014).

The production of soybean oil makes up 20-25 percent of total global fat and oil and 30-35% of total edible vegetable oil production (Tunde-Akintunde, Olajide, & Akintunde, 2005). Linolenic acid makes up around 5 to 11% of soybean oil, whereas linoleic acid makes up 43 to 56%, oleic acid makes up 15 to 33%, and saturated acids make up 11 to 26%. (Collins & Sedgwick, 1959).

Soybean is a species that requires moderate temperatures, especially during flowering, which is a critical period for achieving yield and crop quality, the biological minimum temperature is 17-18°C, while the optimal temperature is 22-25°C. High temperatures during the flowering period can result in significant yield losses due to flower abortion, especially when they are linked to insufficient humidity.

By adapting cropping technology to new climatic changes, high yields can be achieved without the need for additional costs, thus, some authors believe that sowing date is a significant factor in influencing soybean growth, yield (Zhang, Gao, Herbert, Li, & Hashemi, 2010) and seed quality (Rahman, Hapton, & Hill, 2005).

2. MATERIAL AND METHOD

The research was conducted during 2021-2023 at the Agricultural Research and Development Station (ARDS) in Turda on chernozem soil type, which is characteristic of the Transylvanian Plateau. The soil's chemical profile consists of a pH range between neutral and low, humus content between neutral and high, a high amount of nitrogen and potassium, and a moderate amount of phosphorus.

The proposed objectives were achieved through the organization of a two-factor experiment with the following factors: factor A year 2021, 2022, 2023; factor B - sowing period with two graduations: season I - when 5ºC is recorded for three consecutive days in the soil; season II - when 7ºC is recorded for three consecutive days in the soil; factor C - soybean variety with five graduations: Felix (00), Iris TD (00), Ziana TD (00), Raluca TD (0), Isa TD (000) created at ARDS Turda (TD – Turda).

With row spacing of 50 cm and seed rates of 55 germinable grains/m2, the soybeans were sown without fertilization. The seeds were not treated before sowing or bacterized.

Using the analysis of variance method, the statistically processed results were determined to be the least significant difference, LSD, (5, 1%, and 0.1%) (ANOVA, 2015).

The temperature and humidity information presented is compiled from the Turda Meteorological Station, which is situated at 23°47', 46°35', and 427 m elevation.

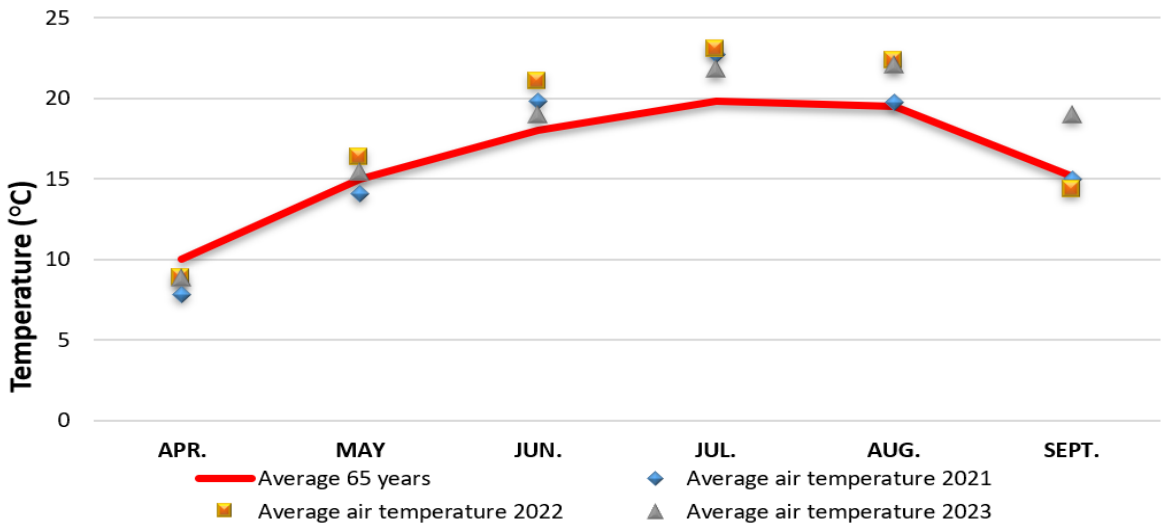

Figure 1. Average temperatures in Turda in the period 2021-2023.

Climatic analysis Figure 1 of the growing season in the three experimental years shows an increase in the average monthly temperature with deviations between 1 and 3.1°C in June, between 2 and 3.3°C in July and between 0.2 and 2.6°C in August, these months being very important for production and quality. An exception according to growing season temperatures are the spring months, especially April, which in the last three years has seen temperatures lower than the multi-year average, which is a hindrance to earlier sowing of the crop.

Rainfall conditions Figure 2 over the three years show a variation in rainfall, with a deficit of 42.8 mm in June and 52.8 mm in July 2022 and 42.8 mm in June 2021. This rainfall deficit coupled with high temperatures had a large impact on soybean cultivation, with two of the three years being considered less favorable years for soybean cultivation.

The rainfall regime was different for the two years, in 2021 the recorded rainfall was within normal limits, except in June when there was a deficit of -39.8 mm, but in 2022 the rainfall deficit in June (-42.8 mm) and July (-52.8 mm) led to a significant drought that affected the development of plant vegetative processes.

Drought coupled with high temperatures played an important role in soybean cultivation, and from a climatic point of view both experimental years can be considered less favorable for soybean.

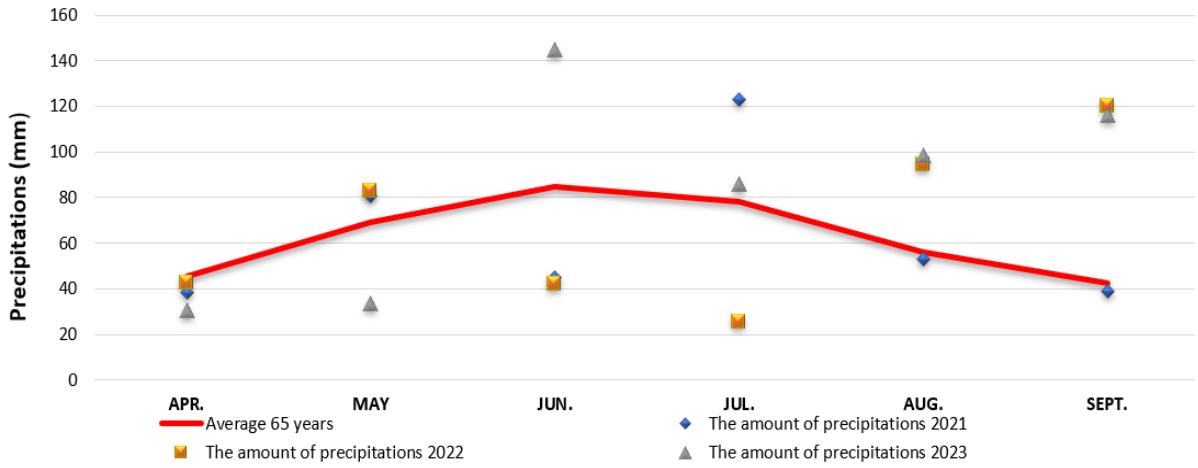

Figure 2. Amount of precipitation recorded in Turda in the period 2021-2023.

3. RESULTS AND DISCUSSIONS

Improving agricultural technologies is the main way in which agriculture can adapt to current and future climate change, thus avoiding its negative influence on good plant growth, with the aim of achieving satisfactory yields per unit area. Soybean quality indices, like yield, can be influenced by factors such as climatic conditions, applied technology or biological material. Changes in technology can have a great influence on the components of crop quality, as stated by Soliman, Rabie, and Ragheb (2007), such an analysis provides an opportunity to make a precise decision on the purpose of sowing soybeans at a specific time.

Although there is an inverse relationship between protein and oil, the results show that after sowing soybeans at two different times, in the conditions at Agricultural Research and Development Station Turda this relationship is not confirmed. Following the change in sowing date, an increase in protein and fat content was observed at early sowing, with the difference from optimal sowing statistically assured as highly significant.

The results obtained are like those obtained by Calviño, Sadras, and Andrade (2003) who stated that sowing affected the fat percentage, the highest percentage being observed at early sowing, but Khan, Akhtar, Ahmad, and Shah (2001) obtained different results for protein content, the highest content being determined at later sowing than at early sowing. In contradiction to our results, Robinson, Conley, Volenec, and Santini (2009) showed that sowing after the optimum period led to an increase in protein content but a reduction in kernel fat content.

Table 1 presents influence of sowing season factor on protein and fat content in soybean (ARDS Turda 2021-2023).

Table 1. Influence of sowing season factor on protein and fat content in soybean (ARDS Turda 2021-2023).

Experimental variant	%		+/- (%)	
	Protein	Fats	Protein	Fats
Sowing season II (Control variant)	33.56 c.v.	20.25 c.v.	0	0
Sowing season I	33.81***	20.48***	0.25	0.22
LDS (5%)	0.08	0.09		
LDS (1%)	0.12	0.13		
LDS (0.1%)	0.20	0.21		

Note: *** = significant at 0.1% probability levels, positive superior values.

Based on experiments, some authors state that the amount of oil and protein in soybeans can vary, depending on the environment (Bianculli, Aguirrezábal, Irujo, & Echarte, 2016) and genotype (Jin et al., 2010).

From the determinations made on the five soybean varieties, compared to Felix, which is the most cultivated soybean variety in Transylvania, the other four varieties behaved differently in terms of protein and fat content in the beans. Iris TD soybean showed a very significant increase in protein content but also a very significant decrease in fat %. Raluca TD had lower quality index values than the control, being a variety with a longer growing season and better production results and where the inverse relationship between yield and quality applies. Ziana TD and Isa TD did not differ significantly from the control variety for either of the two indices analyzed.

Table 2 presents protein and fat content of the five soybean varieties (ARDS Turda 2021-2023).

Table 2. Protein and fat content of the five soybean varieties (ARDS Turda 2021-2023).

Experimental variant	%		+/- (%)	
	Protein	Fats	Protein	Fats
Felix (Control variant)	33.5 c.v.	20.54 c.v.	0	0
Iris TD	35.36***	20.12000	1.86	-0.43
Ziana TD	33.81ns	20.62ns	0.31	0.07
Raluca TD	31.83000	19.82000	-1.67	-0.72
Isa TD	33.93*	20.73ns	0.43	0.18
LSD (5%)	0.39	0.19		
LSD (1%)	0.53	0.25		
LSD (0.1%)	0.69	0.33		

Note: *, *** = significant at 5% and 0.1% probability levels, positive superior values; 000= significant at 0.1% probability levels, negative inferior values; ns= not significant.

Climatic conditions are one of the most important factors that can influence the yield and quality of a crop. Research executed between 2021 and 2023 under different climatic conditions shows that they can influence the protein and fat content of the grain to a quite large extent. Protein percentage was negatively influenced by conditions in 2021, in contrast to the statistically assured increase in fat percentage, a year with low rainfall in June and August correlated with high temperatures, but positively influenced in 2023, when rainfall was quantitatively high enough for the grain formation and filling period and temperatures were above the multi-year average in all months of the grain formation and filling period.

Some authors state that climatic factors are most important in achieving yield and quality in soybean, as Benzian and Lane (1986) found in their research and hypothesized that protein content is four times more dependent on environmental conditions than genotype.

Table 3 presents influence of climatic conditions in the three experimental years on protein and fat content in soybean (ARDS Turda 2021-2023).

The protein percentage showed increases with significant differences for of Felix variety cultivated in 2022, the very significant negative differences in 2021 following the first season cultivation indicate that the protein percentage of Felix is strongly influenced by environmental conditions.

Table 3. Influence of climatic conditions in the three experimental years on protein and fat content in soybean (ARDS Turda 2021-2023).

Experimental variant	%		+/- (%)	
	Protein	Fats	Protein	Fats
Average years (Control variant)	33.69 c.v.	20.37c.v.	0	0
2021	32.96^{00}	20.70**	-0.73	0.33
2022	33.51^{ns}	19.95^{00}	0.17	-0.42
2023	34.59**	20.45^{ns}	0.90	0.08
LSD (5%)	0.32	0.14		
LSD (1%)	0.52	0.23		
LSD (0.1%)	0.98	0.43		

Note: **, = significant at 1% probability levels, positive superior values; 00= significant at 1% probability levels, negative inferior values; ns= not significant.

For variety Raluca TD the differences from the control are mostly positive, except for 2022 where there are decreases in protein content with statistically significant differences.

Protein content of Iris TD and Isa TD varieties was positively influenced, with statistically assured differences as distinctly significant only in year 2022.

Table 4. Protein and fat content for soybean cultivation (ARDS Turda 2021-2023).

Experimental variant	%		+/- (%)	
	Protein	Fats	Protein	Fats
Sowing season II x 2021 x Felix	34.50 c.v.	20.43 c.v.	-	-
Sowing season I x 2021 x Felix	32.80^{000}	21.00*	-1.70	0.57
Sowing season II x 2021 x Iris TD	35.07 c.v.	20.27 c.v.	-	-
Sowing season I x 2021 x Iris TD	35.70	20.20	0.63	-0.07
Sowing season II x 2021 x Ziana TD	33.70 c.v.	20.70 c.v.	-	-
Sowing season I x 2021 x Ziana TD	33.63	20.63	-0.07	-0.07
Sowing season II x 2021 x Raluca TD	27.50 c.v.	21.03 c.v.	-	-
Sowing season I x 2021 x Raluca TD	28.70**	20.77	1.20	-0.27
Sowing season II x 2021 x Isa TD	34.10 c.v.	20.93 c.v.	-	-
Sowing season I x 2021 x Isa TD	33.87	21.00	-0.23	0.07
Sowing season II x 2022 x Felix	32.13 c.v.	20.07 c.v.	-	-
Sowing season I x 2022 x Felix	33.23*	20.20	1.10	0.13
Sowing season II x 2022 x Iris TD	33.70 c.v.	20.17 c.v.	-	-
Sowing season I x 2022 x Iris TD	35.23**	19.80	1.53	-0.37
Sowing season II x 2022 x Ziana TD	32.93 c.v.	20.30 c.v.	-	-
Sowing season I x 2022 x Ziana TD	33.03	20.43	0.10	0.13
Sowing season II x 2022 x Raluca TD	35.13 c.v.	18.30 c.v.	-	-
Sowing season I x 2022 x Raluca TD	33.87^{00}	19.23***	-1.27	0.93
Sowing season II x 2022 x Isa TD	32.33 c.v.	20.53 c.v.	-	-
Sowing season I x 2022 x Isa TD	33.53**	20.47	1.2	-0.07
Sowing season II x 2023 x Felix	34.27 c.v.	20.77 c.v.	-	-
Sowing season I x 2023 x Felix	34.07	20.80	-0.20	0.03
Sowing season II x 2023 x Iris TD	36.63 c.v.	19.87 c.v.	-	-
Sowing season I x 2023 x Iris TD	35.83	20.40*	-0.80	0.53
Sowing season II x 2023 x Ziana TD	34.70 c.v.	20.70 c.v.	-	-
Sowing season I x 2023 x Ziana TD	34.83	20.93	0.13	0.23
Sowing season II x 2023 x Raluca TD	32.03 c.v.	19.27 c.v.	-	-
Sowing season I x 2023 x Raluca TD	33.77***	20.33***	1.73	1.07
Sowing season II x 2023 x Isa TD	34.67 c.v.	20.47 c.v.	-	-
Sowing season I x 2023 x Isa TD	35.07	20.97*	0.40	0.50
LSD (5%)	0.88	0.44		
LSD (1%)	1.17	0.60		
LSD (0.1%)	1.54	0.80		

Note: *, **, *** = significant at 5% 0.1% and 0.1% probability levels, positive superior values; 000= significant at 0.1% probability levels, negative inferior values; ns= not significant.

Fat percentage was less influenced by the triple interaction, with differences from the control observed only in Raluca TD, which in 2022 and 2023 showed very significant increases in fat content following its early season cultivation.

Results obtained by Księżak and Bojarszczuk (2022) show that sowing date (season) and weather conditions during the growing season significantly affected the quality of seed yield, indicating a greater influence of total rainfall on protein content.

The analysis by the interaction of the three experimental factors shows that five varieties reacted differently to the technological factor and to the environmental conditions, as reported by Pierozan et al. (2017) following in their research some varieties can be recommended for early sowing while others are useful for delayed sowing.

Table 4 presents protein and fat content for soybean cultivation (ARDS Turda 2021-2023).

4. CONCLUSION

Although early sowing of soybeans has attracted attention because it offers benefits in harnessing early rainfall, avoids drought and high summer temperatures, for quality indices, early sowing ensures a significant increase in protein and fat percentage.

The results present that weather factors are very important in production, but heat stress during the growing season has a significant influence in achieving high quality indices.

According to the results obtained it can be observed that the biological material represented by the five varieties responded differently to the climatic conditions of the three experimental years, from this we conclude that each soybean variety has a better yield of some qualitative index for a given sowing period, some varieties can be recommended for early sowing while others for late sowing.

Funding: This research is supported by Agricultural Research and Development Station Laboratory Technologies and Mechanization (Grant number: ADER 1.4.1 / 19.07.2023. Project period 2023-2026).
Institutional Review Board Statement: The Ethical Committee of the Agricultural Research and Development Station Turda, Romania has granted approval for this study.
Transparency: The authors state that the manuscript is honest, truthful, and transparent, that no key aspects of the investigation have been omitted, and that any differences from the study as planned have been clarified. This study followed all writing ethics.
Competing Interests: The authors declare that they have no competing interests.
Authors' Contributions: All authors contributed equally to the conception and design of the study. All authors have read and agreed to the published version of the manuscript.

REFERENCES

ANOVA. (2015). *PoliFact and duncan's test pc program for variant analyses made for completely randomized polifactorial experiences* Romania Staţia Meteo Turda: USAMV Cluj-Napoca.

Benzian, B., & Lane, P. W. (1986). Protein concentration of grain in relation to some weather and soil factors during 17 years of English winter-wheat experiments. *Journal of the Science of Food and Agriculture, 37*(5), 435-444. https://doi.org/10.1002/jsfa.2740370502

Bianculli, M. L., Aguirrezábal, L. A., Irujo, G. A. P., & Echarte, M. M. (2016). Contribution of incident solar radiation on leaves and pods to soybean seed weight and composition. *European Journal of Agronomy, 77*, 1-9. https://doi.org/10.1016/j.eja.2016.03.002

Calviño, P. A., Sadras, V. O., & Andrade, F. H. (2003). Quantification of environmental and management effects on the yield of late-sown soybean. *Field Crops Research, 83*(1), 67-77. https://doi.org/10.1016/s0378-4290(03)00062-5

Collins, F., & Sedgwick, V. (1959). Fatty acid composition of several varieties of soybeans. *Journal of the American Oil Chemists Society, 36*(12), 641-644. https://doi.org/10.1007/bf02640276

Fekadu, G., Hussein, M., & Getinet, A. (2009). Genotype × enivronment interactions and stability of soybean for grain yield and nutrition quality. *African Crop Science Journal, 17*(2), 87-99.

Jin, J., Liu, X., Wang, G., Mi, L., Shen, Z., Chen, X., & Herbert, S. J. (2010). Agronomic and physiological contributions to the yield improvement of soybean cultivars released from 1950 to 2006 in Northeast China. *Field Crops Research*, *115*(1), 116-123.

Khan, A. Z., Akhtar, M., Ahmad, R., & Shah, P. (2001). Planting date and plant density effects on protein and oil contents of soybean varieties under the environmental conditions of Peshawar, Pakistan. *Online Journal of Biological Sciences*, *1*, 126-128. https://doi.org/10.3923/jbs.2001.126.128

Księżak, J., & Bojarszczuk, J. (2022). The seed yield of soybean cultivars and their quantity depending on sowing term. *Agronomy*, *12*(5), 1066. https://doi.org/10.3390/agronomy12051066

Medic, J., Atkinson, C., & Hurburgh, C. R. (2014). Current knowledge in soybean composition. *Journal of the American oil Chemists' Society*, *91*, 363-384. https://doi.org/10.1007/s11746-013-2407-9

Pierozan, J. C., Kawakami, J., Schwarz, K., Umburanas, R. C., Del Conte, M. V., & Müller, M. M. L. (2017). Sowing dates and soybean cultivars influence seed yield, oil and protein contents in subtropical environment. *The Journal of Agricultural Science*, *9*(6), 188-198.

Rahman, M. M., Hapton, J. G., & Hill, M. J. (2005). The effect of time of sowing of soybean seed quality. *Seed Science and Technology*, *33*, 687-697. https://doi.org/10.15258/sst.2005.33.3.16

Robinson, A. P., Conley, S. P., Volenec, J. J., & Santini, J. B. (2009). Analysis of high yielding, early-planted soybean in Indiana. *Agronomy Journal*, *101*(1), 131-139. https://doi.org/10.2134/agronj2008.0014x

Sin, G. (2000). *Modern technologies for field plant culture*. Bucharest: Ceres Publishing House.

Soliman, M., Rabie, E., & Ragheb, S. (2007). Response of soybean yield to late sowing dates. *Arab Universities Journal of Agricultural Sciences*, *15*(1), 51-59.

Thrane, M., Paulsen, P. V., Orcutt, M. W., & Krieger, T. M. (2017). Soy protein: Impacts, production, and applications in sustainable protein sources; Nadathur, S.R., Wanasundara, J.P.D., Scanlin, L., Eds. In (pp. 23–45). Cambridge, MA, USA: Academic Press.

Tunde-Akintunde, T., Olajide, J., & Akintunde, B. (2005). Mass-volume-area related and mechanical properties of soybean as a function of moisture and variety. *International Journal of Food Properties*, *8*(3), 449-456. https://doi.org/10.1080/10942910500267513

Yilmaz, N. (2003). The effects of seed rate on yield and yield components of soybean (Glycine max L. Merill). *Pakistan Journal of Biological Sciences*, *6*, 373–376. https://doi.org/10.3923/pjbs.2003.373.376

Zhang, Q., Gao, Q., Herbert, S., Li, Y., & Hashemi, A. (2010). Influence of sowing date on phenological stages, seed growth and marketable yield of four vegetable soybean cultivars in North-Eastern USA. *African Journal of Agricultural Research*, *5*(18), 2556-2562.