Romanian Journal for Plant Protection, Vol. XVI, 2023
ISSN 2248 – 129X, ISSN-L 2248 – 129X

EFFECT OF THE SOWING SEASON AND CLIMATIC CONDITIONS ON WEEDS IN SOYBEAN CROP

Alina Șimon[1], Raluca Rezi[1], Camelia Urdă[1], Marius Bărdaș[1], Adrian Ceclan[1*], Florin Russu[1], Felicia Chețan[1], Alin Popa[1,2]*

[1]Agricultural Research and Development Turda, 27 Agriculturii, Cluj, Romania
[2] University of Agricultural Sciences and Veterinary Medicine, Cluj-Napoca, Romania

*Corresponding author: e-mail: camelia.urda@scdaturda.ro; adrian.ceclan@scdaturda.ro
Agricultural Research and Development Station Turda
27 Agriculturii , 401100, Turda, Cluj, Romania

http://www.doi.org/10.54574/RJPP.16.12

Abstract: Weed competition for water, light and nutrients can cause yield losses of up to 80-90% if effective weed reduction measures are not taken in the soybean crop. Research on the influence of sowing time on the degree of weeding of soybeans was carried out at the Turda Agricultural Research and Development Station, during 2021-2023. Weeds were determined numerically and gravimetrically. Weed control was carried out mechanically, during the vegetation period, two weed controls were executed, the first in the phase of the appearance of the first trifoliate leaf and the second two weeks after the first. The dominant dicotyledonous species were *Chenopodium album, Hibiscus trionum, Polygonum convolvulus, Xanthium strumarium*, and for the monocotyledonous species *Setaria glauca* and *Echinochloa crus-galli* were identified, both in the first and the second sowing season, the difference between the two sowing season being given by the total number of species and the number of weeds identified per plot. The soybean crop was removed from weeds by the two swaths, and the plant was re-weeded with the same species as in the spring after the flowering period. Weeds that appeared during the latter part of the soybean growing season did not cause any significant harm to the crop. The number of weeds per plot and soybean yield were influenced by the sowing season and climatic conditions. The best outcome was achieved when soybeans were sown during the first season.

Keywords: weeds, sowing season, yield, soybean

INTRODUCTION

Climate change involves not only an increase in temperatures but a change in several elements, with drought being one of the most critical environmental stressors that reduce plant production worldwide (Mahajan & Tuteja, 2005).

Almost 90% of the world's cultivated land is experiencing one or more abiotic stresses, the most common of which, as well as the most severe, are drought, salinity and extreme temperatures (Roussos, 2020).

Changes in temperature and precipitation will also very likely extend the range of insects, weeds and diseases. This could lead to a greater need for weed and pest control (Ziska et al., 2016) from agricultural crops.

Soya (*Glycine max* L. Merril.) is one of the most important and valuable plants grown worldwide. Due to various uses in human and animal nutrition, in various branches of industry as well as in agricultural landings, the interest in growing this plant is growing.

Weeds are considered to be harmful to agricultural yield (Meseldzija et al., 2020), especially soybean crop, this being a plant that requires special attention in terms of combating weeds, as well as, especially in the first phenophase of growth, when the competition of crop plants is reduced in the fight against weeds (Wilson, 1988).

Weed infestation is a major cause of the decrease in soybean production, therefore, correct weed management is one of the most important and expensive steps in soybean production (Stefanic et al., 2022).

The main sources of weeding of agricultural crops are given by the existing reserve of weed seeds in the arable soil layer and the unconditional seed used for sowing agricultural crops (Partal et Oltenacu, 2022).

The purpose of this paper is to analyze the effect of changing the timing of sowing and climatic conditions in the growing season on the soya culture as well as the degree of weed re-infestation, following the use of the mechanical method of reducing them.

MATERIALS AND METHODS

In line with the current European legislation that aims to reduce the use of pesticides by 50% by the year 2030 (source: https://ec.europa.eu/commission/presscorner/detail/), there is a need for more research to identify weed reduction methods in soybean crops. This is necessary to meet the EU requirements which are geared towards reducing pollution, and addressing climate and environmental challenges.

From 2021 to 2023, the Agricultural Research and Development Station Turda (ARDS Turda) conducted an experiment to study the effect of the sowing time on plant development, degree of flowering and production, and quality of the harvest.

To achieve the objectives, two sowing seasons were executed: sowing season I - when the soil temperature was recorded for three consecutive days at 5°C, and sowing season II - when the soil temperature was recorded for three consecutive days at 7°C. The type of soil for this study is chernozem, the characteristic soil of the Transylvanian Plateau. As a chemical description, the soil has a weakly alkaline pH, neutral to high humus content, well-stocked in nitrogen and potassium, medium supplied in phosphorus.

The soybeans were planted at a density of 55 germinating grains per square meter, with a row spacing of 50 cm. No fertilizers were used, and the seeds were neither treated nor inoculated with bacteria before planting. The soybean variety used was Felix (00), developed by the Agricultural Research and Development Station Turda (ARDS) in Turda.

During the study, the researchers collected weeds from different species and weighed them before and after drying them in an oven for 16 hours at 70°C. They used mechanical methods to control the weeds, including two slingshots during the vegetation period. The first slingshot was used when the first trifoliate leaf appeared, while the second hoeing was used two weeks after the first one. The results obtained were statistically processed by the method of variance analysis and establishing the smallest significant difference - LSD - (5%, 1% și 0.1%) (ANOVA, 2015).

The climate data presented in this paper are from Turda Meteorological Station, located on the longitude coordinates: 23º47'; latitude 46º35'; altitude 427 m.

During the soybean crop's growing season, average temperatures were higher than the multiannual average, except for April, which had below average temperature values in all three years. In the summer of 2022 (Figure 1) there were the highest deviations from the average (2.8-3.3 C).

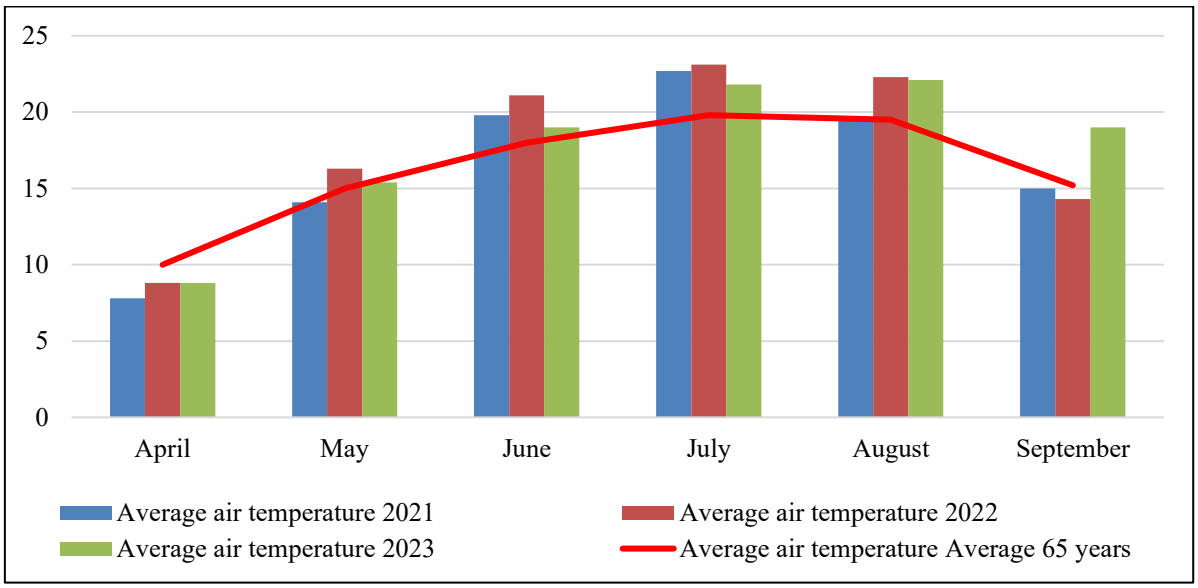

Figure 1. The thermal regime of the growing season of soybean crop (ºC)

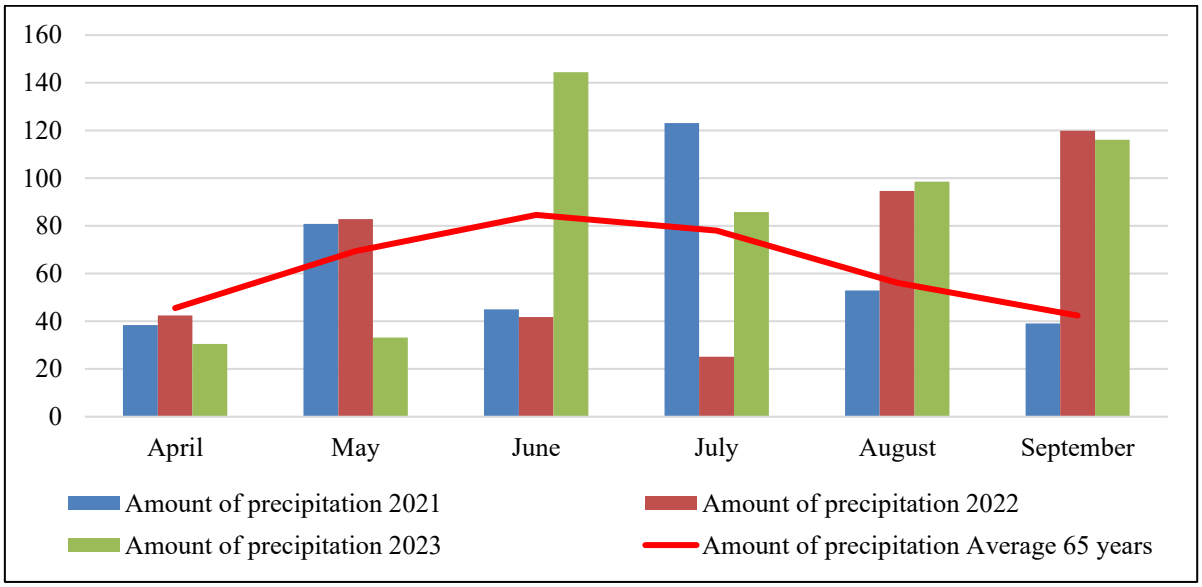

Figure 2. The rainfall regime from the vegetation period of the soybean crop (mm)

The amount of rainfall in the area varied over the past few years. In 2021, the recorded rainfall was normal except for June when there was a deficit of -39.8 mm. However, in 2022, there was a significant drought due to a precipitation deficit in June (-42.8 mm) and July (-52.8 mm), which affected the growth and development of vegetation. The year 2023 also had a significant rainfall deficit in the first two months of the growing season, but it was followed by an excess of rainfall every month of the growing season. The highest amount of rainfall was recorded in June (144.5 mm) (Figure 2).

The drought, combined with high temperatures, had a negative impact on soybean cultivation. Both experimental years could, therefore, be considered less favorable for

soybeans.

RESULTS AND DISCUSSIONS

Due to the variable climatic conditions, the soybean crop was sowed on different dates for each year. In order to sow the crop, specific temperature conditions needed to be met for each sowing season. Table 1 shows that sowing was carried out only when the soil temperature was between 5 and 7 C.

Table 1. Date of sowing soybean crop

Sowing date			
Year	2021	2022	2023
Sowing season I	13.04.2021	08.04.2022	12.04.2023
Sowing season II	26.04.2021	09.05.2022	24.04.2023

The emergence of soybean crop has been delayed due to low spring temperatures. The number of days from sowing to emergence varies with different years. Table 2 shows the dates of emergence for each year and period of sowing.

Table 2. Date of emergence of soybean crop

Date of emergence			
Year	2021	2022	2023
Sowing season I	04.05.2021	27.04.2022	02.05.2023
Sowing season II	10.05.2021	19.05.2022	18.05.2023

A numerical analysis was conducted to determine the number of weeds in the crop before the first hoeing. The results showed that sowing the crop earlier can lead to a lower number of weeds emerging per unit area, as compared to sowing it at a later time. This is demonstrated in Table 3.

In the experimental field, different species of weeds were found to be infested, mainly the annual weed species, with dicotyledons being the most frequent. The most common weed species identified were *Chenopodium album, Hibiscus trionum, Polygonum convolvulus*, and *Xanthium strumarium*. Among monocotyledonous species, *Setaria glauca* and *Echinochloa crust-galli* were found to be the most widespread. However, some experts consider *Echinochloa crust-galli* to be a troublesome weed worldwide (Lawrence et al., 2020).

During the research period, climatic conditions greatly influenced the appearance of weeds, leading to the observation of four specific species (*Amaranthus retroflexus, Chenopodium hybridum, Delphinium consolida*, and *Galisoga parviflora*) in 2023. Precipitation is a significant factor that affects the distribution of weed species and their competitiveness within the weed community, as noted by Daramola et al. in 2019. Weeds, like crop plants, have a minimum temperature required to emerge and go through certain stages of development, and by sowing earlier, weed emergence before the crop could be avoided, regardless of the climatic conditions of the three years of study.

Table 3. Species and number of weeds present in soybean crop before the first crop hoeing

Nr. crt.	Weed species present	Number of weeds /m²					
		Sowing season I (5ºC in soil)			Sowing season II (7ºC in soil)		
		2021	2022	2023	2021	2022	2023
1	*Amaranthus retroflexus*	0	0	2	0	0	4
2	*Chenopodium album*	3	2	3	6	5	6
3	*Chenopodium hybridum*	0	0	2	0	0	4
4	*Delphinium consolida*	0	0	3	0	0	5
5	*Echinochloa crus-galli*	4	3	4	6	5	6
6	*Galisoga parviflora*	0	0	2	0	0	6
7	*Hibiscus trionum*	2	2	5	3	4	7
8	*Polygonum convolvulus*	2	1	3	2	3	2
9	*Polygonum persicaria*	1	1	2	1	2	6
10	*Setaria glauca*	4	4	4	10	8	8
11	*Viola ervensis*	1	1	1	2	3	0
12	*Veronica sp.*	1	2	2	2	2	3
13	*Xanthium strumarium*	3	2	2	5	3	3
Total		21	18	34	37	35	60

During the second hoeing of the soybean crop, a study was conducted to identify the weed species present. The results showed a significantly higher number of weeds in the second sowing season, compared to the first sowing season for all the years studied. The number of weeds in the second season was almost double that of the first season, as shown in Table 4.

The soybean plants that emerged in the first sowing season were able to utilize the high temperatures during the day to develop much better than those in the second sowing season. As a result, they were able to cover the ground more effectively, which made it harder for the weeds in the process of emerging to grow.

Table 4. Species and number of weeds present in soybean crop before the second hoeing

Nr. crt.	Weed species present	Number of weeds /m²					
		Sowing season I (5ºC in soil)			Sowing season II (7ºC in soil)		
		2021	2022	2023	2021	2022	2023
1	*Amaranthus retroflexus*	1	1	1	2	1	3
2	*Chenopodium album*	3	2	3	6	5	6
3	*Chenopodium hybridum*	1	1	1	2	2	2
4	*Delphinium consolida*	1	1	1	1	1	5
5	*Echinochloa crus-galli*	4	3	2	6	5	3
6	*Galinsoga parviflora*	2	1	2	4	3	6
7	*Hibiscus trionum*	2	2	1	3	4	2
8	*Polygonum convolvulus*	2	1	1	2	3	2
9	*Polygonum persicaria*	1	1	2	1	2	4
10	*Silene noctiflora*	1	2	0	1	3	0
11	*Setaria glauca*	4	4	4	10	8	6
12	*Viola ervensis*	1	1	0	2	3	0
13	*Veronica sp.*	1	2	0	2	2	0
14	*Xanthium strumarium*	3	2	2	5	3	4
Total		27	24	20	47	45	43

After two hoeing operations, the soybean crop was cleared of weeds. Reinfestation with weeds was achieved after the flowering period, with the same species in spring. The weeds that emerged after the second hoeing were suppressed by soybeans, having less development, and showing a low competitive capacity with soybean plants, their number and mass are influenced by climatic conditions in the vegetation period.

The year (temperature conditions and precipitation) has the highest impact on composition differences in the weed community, followed by the sowing season. The species *Galinsoga parviflora* was the one that prevailed at the time of harvest, although this species was identified in soybean culture only in 2023, followed by the species *Chenopodium album, Echinochloa crust-galli, Setaria glauca* (Table 5).

Table 5. Species and number of weeds present in soybean crop before harvest

Nr. crt.	Weed species present	Number of weeds/m^2					
		Sowing season I (5ºC in soil)			Sowing season II (7ºC in soil)		
		2021	2022	2023	2021	2022	2023
1	*Chenopodium album*	1	1	2	1	1	3
2	*Convolvulus arvensis*	0	1	1	1	0	0
3	*Echinochloa crus-galli*	1	1	4	1	2	4
4	*Galinsoga parviflora*	0	0	13	0	0	19
5	*Silene noctiflora*	0	0	0	0	0	1
6	*Setaria glauca*	1	0	3	0	1	8
7	*Stachys annua*	0	0	0	0	0	1
8	*Veronica sp.*	0	0	1	0	0	1
9	*Xanthium strumarium*	1	0	0	2	2	0
Total		4	3	24	5	6	37

Weed re-infestation of the crop was made after soybean flowering, a period in which the soybean crop can no longer be affected quantitatively, the species of weeds emerged were in small numbers so that although they developed by the time of harvest, their vegetative mass was reduced. In the third year of the study, the *Galinsoga parviflora* species was found in a high number and with a high vegetal mass, which contributed a very high percentage to the weeding of the crop before harvest, especially for the second sowing season (Table 6).

Table 6. Green and dry mass of weeds before harvesting the crop

Variant		Monocotyledonous		Dicotyledonous	
		GM (g)	DM (g)	GM (g)	DM (g)
2021	Sowing season I	0,4	0,1	2,1	0,9
	Sowing season II	1,12	0,7	2,8	1,1
2022	Sowing season I	0,8	0,3	3,9	1,8
	Sowing season II	1,5	0,8	4,1	2,0
2023	Sowing season I	27,5	6,8	69,6	13,3
	Sowing season II	19,2	5,0	102,2	15,6

- GM- green mass; DM-dry matter;

Following the fifth evaluation report of the Intergovernmental Panel on Climate Change (IPCC), the increase in the global average surface temperature for the period 2016-2035 in relation to 1986-2005 will likely be in the range of 0.3°C up to 0.7 °C (IPCC) which forces us to take urgent measures to reduce the impact of climate change on agriculture and beyond.

The fact that the sowing season and climatic conditions influenced both the number of weeds per plot and the yield of soybeans, as well, the best results being obtained in the variant when soy was sown in the first sowing season, shows us that by modifying some technological stages, without additional costs, the negative effects of global warming can be avoided (Table 7).

The average output of the Felix variety in the two sowing season ranged from 2313 to 2531 kg/ha, about 50% of the genetic potential of this variety, this is due in particular to the unfavorable climatic conditions of the first two years, fact also found by Negrea et al. (2022), noticing insufficient moisture in soybean breeding phases with negative consequences on yield. However, the Felix variety reacts very well to earlier sowing, the yield increase of 218 kg/ha made in the first sowing season is statistically assured as very significant positive.

Table 7. The influence of sowing season on soybean yield

Variant	Yield		+/- (kg/ha)	Significance
	kg/ha	%		
Sowing season II (7ºC în sol) (control)	2313	100	0	Control.
Sowing season I (5ºC în sol)	2531	109	218	***
LSD (p 5%) 50	LSD (p 1%) 76		LSD (p 0.1%) 122	

Variable climatic conditions in the growing season greatly influenced the yield of soybeans, the yield differences between a year with rainfall regime favorable to soybean crop and a dry year being 2070 kg/ha, as Mos et al., states (2010). Climate change can have various effects on yield, depending on the type of soil and technological measures applied in agricultural crops.

Climatic conditions were and will be one of the most important factors of yield, the data in Table 8 being the result of the interaction of temperatures and precipitation during the growing season. Soybean yield in 2022, of only 1425 kg/ha, being the proof that the lack of rainfall in the flowering-filling period of the beans significantly reduces the yield of a crop, which is, at the opposite pole is the year 2023 (3495 kg/ha), in which temperatures and precipitation recorded satisfactory values for soybean crop.

Table 8. The influence of climatic conditions on soybean production

Variant	Yield		+/- (kg/ha)	Significance
	kg/ha	%		
Average of years (control)	2422	100	0	Mt.
2021	2347	97	-76	-
2022	1425	59	-997	000
2023	3495	144	1072	***
LSD (p 5%) 93	LSD (p 1%) 155		LSD (p 0.1%) 289	

The rainfall in July-September, correlated with a warm regime can favor late infestations of crops so that at harvest the degree of weeding is very high, making the stockpile of weed seeds accumulating in the soil keep growing. However, production capacity is the result of the complex interaction of plants through their genetic potential and a set of environmental factors (Melnyk et al., 2022).

Soybean yield made from the interaction of the climatic conditions of the three years and the sowing of soy during the two sowing seasons shows the importance of applying an appropriate technology and meeting thermal and hydric conditions favorable to obtaining high

yields at low costs. The Felix variety recorded the highest yield after sowing the crop earlier than normal, under the conditions of 2023 (3584 kg/ha).

Table 9. The influence of the interaction of experimental factors on soybean yield

Varianta	Yield		+/-	Significance
	kg/ha	%	(kg/ha)	
Media anilor x Sowing season I (martor)	2531	100	0	Mt.
2021 x Sowing season I	2382	94	-149	0
2022 x Sowing season I	1627	64	-904	000
2023 x Sowing season I	3584	142	1053	***
Media anilor x Sowing season II (martor)	2313	100	0	Mt.
2021 x Sowing season II	2311	100	-2	-
2022 x Sowing season II	1223	53	-1090	000
2023 x Sowing season II	3405	147	1092	***
LSD (p 5%) 112	LSD (p 1%) 180		LSD (p 0.1%) 321	

CONCLUSIONS

The analysis of hydrothermal conditions indicates that the moisture intake and temperature during the soybean growing season varied over three years, and this had a significant impact on the production capacity. By adjusting the timing of sowing, it is possible to introduce crop varieties with a longer vegetation period, which are typically more productive.

Based on the results obtained in the last three years, we can conclude that the modification of the sowing season can be an effective and cheap method to reduce weeds in the soybean crop.

ACKNOWLEDGEMENTS

This work was supported by a grant from the Ministry of Agriculture and Rural Development through the ADER 2023-2026 program, project no. 141/19.07.2023, ADER 1.4.1 "Perfecționarea metodelor de combatere a buruienilor la cultura de soia, în vederea creșterii eficienței economice prin reducerea numărului de tratamente și a impactului negativ asupra mediului"

REFERENCES

DARAMOLA OS, ADEYEMI OR, ADIGUN JA, ADEJUYIGBE CO. (2019). Distanța dintre rânduri și metodele de gestionare a buruienilor influențează creșterea și randamentul de soia. Agric Trop Subt., 52(2): 59-71.

LAWRENCE, B.H.; HYDRICK, H.T.; BOND, J.A.; GOLDEN, B.R.; ALLEN, T.W.; SANDERS, T. (2020). Weed Control and Soybean (*Glycine max* (L.) Merr) Response to Mixtures of a Blended Foliar Fertilizer and Postemergence Herbicides. *Agronomy*, *10*, 1719.

MAHAJAN, S., TUTEJA, N. (2005). Cold, salinity and drought stresses: an overview. Archives of Biochemistry and Biophysics, 444(2), 139-158.

MELNYK, A., ROMANKO, Y., DUDKA, A., CHERVONA, V., BRUNYOV, M., SOROKOLIT, E. (2022). Ecological elasticity of soybean varieties' performance according to climatic factors in Ukraine. *AgroLife Scientific Journal*, *11*(2).

MESELDŽIJA, M.; RAJKOVIĆ, M.; DUDIĆ, M.; VRANEŠEVIĆ, M.; BEZDAN, A.; JURIŠIĆ, A.; LJEVNAIĆ-MAŠIĆ, B. (2020). Economic Feasibility of Chemical Weed Control in Soybean Production in Serbia. *Agronomy*, *10*, 291.

MOSS, R.H., EDMONDS, J.A., HIBBARD, K.A., MANNING, M.R., ROSE, S.K., VAN VUUREN, D.P. (2010). The next generation of scenarios for climate change research and assessment. Nature: 463: 747–756.
NEGREA, A., R. REZI, C. URDĂ, L. PĂCURAR, T. RUSU. (2022). Soybean yield and quality response to foliar fertilization. AgroLife Scientific Journal, 11(1).
ROUSSOS, P. A. (2020). Climate change impacts on fruit trees and mitigation strategies of adverse effects. *AgroLife Scientific Journal*, *9*(2). 269-276
PARTAL E., OLTENACU C. V. (2022). Effects of agrotechnical measures on weed dynamics and water balance in soil for different crops. Scientific Papers. Series A. Agronomy, Vol. LXV, Issue 2, ISSN 2285-5785, 292-299.
PATEL MM, PATEL AI, PATEL IC, TIKKA SBS, HENRY A, KUMAR D, SINGH NB. (2003). Weed control in cowpea under rain fed conditions. In: Proceedings of the National Symposium on Arid Legumes, for Food Nutrition. Security and promotion of Trade. Advances in Arid Legumes Research. Hisar, India. 2003; 203-206;
STEFANIC, E.; RASIC, S.; LUCIC, P.; TOLIC, S.; ZIMA, D.; ANTUNOVIC, S.; JAPUNDŽIĆ-PALENKIĆ, B.; STEFANIC, I. (2022). Weed Community in Soybean Responses to Agricultural Management Systems. *Agronomy*, *12*, 2846.
ZISKA, L., CRIMMINS A., AUCLAIR A., MCLEROY S., GAROFALO J., KHAN A. S., LOLADZE I., PÉREZ DE LEÓN A., SHOWLER A., THURSTON J., WALLS I. (2016). Ch. 7: Food safety, nutrition, and distribution. In: *The impacts of climate change on human health in the United States: A scientific assessment.* U.S. Global Change Research Program, Washington, DC, 197.
WILSON, J. B. (1998). The effect of initial advantage on the course of plant competition. Oikos, 51: 19–24.
***https://ec.europa.eu/commission/presscorner/detail/en/qanda_22_3694.
***ANOVA 2015. PoliFact and Duncan's test pc program for variant analyses made for completely randomized polifactorial experiences, USAMV Cluj-Napoca, Romania.
*** Meteorological Station Turda.
*** https://www.ipcc.ch/report/ar5/syr/