Ukrainian Journal of Ecology

Ukrainian Journal of Ecology, 2021, 11(4), 11-17, doi: 10.15421/2021_193

ORIGINAL ARTICLE

Influence of weather and climatic conditions on soybean yield

M. Tsekhmeistruk[1], O. Pankova[1], V. Kolomatska[2], L. Kobyzieva[2], M. Artiomov[1], K. Sirovitskiy[1]

[1]Kharkiv Petro Vasylenko National Technical University of Agriculture, Ukraine
[2]The Plant Production Institute named after V.Ya. Yuriev of NAAS
**Corresponding author E-mail: tsekhmeystruk@gmail.com, pankova_oksana@ukr.net*

Received: 05.05.2021. Accepted: 05.06.2021.

The growth and germination of agricultural plants are determined by the soil and climatic conditions of the territory. In 75-80% of years, the climatic conditions are abnormal. In addition, the water regime of the soil is made worse not only by insufficient rainfall during the growing season, but also due to the reduction of humus reserves in the arable layer. All factors that ensure the plant's germination are closely interrelated. Changing one of them causes changing others. The study aimed to research the influence of weather and climatic conditions (average daily air temperatures and precipitation during the growing season) on the level of soybean yield. Field research was conducted in the period 2004-2020 at the The Plant Production Institute named after V.Ya. Yuriev of NAAS. On average, over the years of research (2004-2020), the deviation in the average daily temperature during the soybean growing season is plus 2.21°C. There is noted significant warming in the period August-September by 2.41-2.21°C. Insufficient moisture was observed during the nine years and excess – during the eight years. Calculations of linear regression show a constant and stable increase in average daily temperature for all months. Regression analysis of the precipitation amount for the study period predicts an increase in this indicator only in April and May, the regression equation - $y = 0.9419x + 22.658$ and $y = 1.7973x + 41.724$. June and July - decrease in the amount of precipitation, equations $y = -2.9848x + 98.169$ and $y = -1.799x + 82.215$, in August - $y = -2.3203x + 58.907$. During 2004-2020, with all backgrounds of mineral nutrition, the precipitation of July had a positive effect on the crop (r = from 0.501 to 0.555). May precipitation - only in control variant - r = 0.408 and in the case of the $N_{60}P_{60}K_{60}$ background + 30 t/ha of manure (r = 0.318). For the last research period of 2014-2020, this indicator has a much higher positive impact on crop yields in all months and all backgrounds of mineral nutrition, compared to previous research periods.

Keywords: daily average temperature, precipitation amount, soybean yield, correlation coefficient, influence.

Introduction

The growth and development of agricultural plants is determined by the soil and climatic conditions of the territory (Valkov, 1986). In 75-80% of years, the climatic conditions are abnormal. In addition, the water regime of the soil is deteriorated not only by insufficient rainfall during the growing season, but also due to the reduction of humus reserves in the arable layer. Therefore, when growing oilseeds, it is necessary to adhere to the principle of maximum accumulation of moisture in the autumn-winter period with simultaneous protection of the soil from erosion (Tsilyurik, 2019, Shashkov et al., 2018). All factors that ensure the development of plants are closely interrelated. Changing one of them causes changing others. Weather conditions during the crop growing season cause significant fluctuations in productivity not only in individual regions and countries, but also on continents. Thus, fluctuations in yields in recent years have increased from 2.26 to 3.36%. The instability of crop production is characteristic of developing countries and industrialized countries (Climate change, 2019; The change, 2011). The most significant decrease in plant productivity is observed in cases of coincidence of "critical" periods of ontogenesis with the action of abiotic stresses (seedling - drought, lowering the temperature, flowering - drought, and rising temperature) (Skazkin, 1961).

Soybean, like all legumes, has value in crop rotation. It can be combined with itself, but monoculture is excluded. It should be taken in consideration that during the early stages of growth in soybeans, the root system develops strongly, and plant growth is slowed down. This makes it less competitive in weed control. Therefore, the best predecessors for soybeans are slightly weedy fields after winter and spring cereals. These crops release fields faster than others, which allows for repeated tillage in the system of essential soil preparation. Soybean is also planted after row crops - corn, potatoes, beets, and vegetables. It returns to the previous place not earlier than in 3-4 years. Unsuitable predecessors are other legumes and perennial legume grasses (hosts of pathogens of root rot) and crop - hosts of sclerotinia pathogens, such as sunflower or cruciferous crops. The share of crops susceptible to sclerotiniosis (soybeans, sunflower, and rapeseed) in crop rotation should not exceed 33%. The predecessors must leave the field free of pathogens.

Soybeans, as a legume, are a valuable predecessor for other crop rotations. Leaving a well-developed root system with nodule bacteria in the soil after harvesting furthers the accumulation of nitrogen (60-80 kg/ha) and improves the soil's structure and fertility. Soybeans use low soluble nutriment from the bottom layers of the soil and include them in the food cycle. On average, it leaves about 60–80 kg of nitrogen, 20–25 kg of phosphorus, and 30–40 kg of potassium per 1 ha (Soybean growing technology, 2020).

Soybean is unable to take repeated sowing because there is a "soil exhaustion", with rotting germinated seeds, seedlings die, reduced size and activity of the symbiotic apparatus, as well as fields, are weeded heavily, pests and diseases accumulate and spread (Osipchuk et al., 2018, Gortlevsky, 1998). Soybean needs a well-fluffed arable layer for the normal development of the root system and the functioning of nodule nitrogen-fixing bacteria (Adamen, 1999). The application of technologies for growing advanced varieties, which are developed on the principles of adaptive crop production, is a significant means of increasing crop production. Improving the efficiency of all factors of technologies, intensification of growing crops should be based on the current level of agricultural technology. This requires a reconsideration of soybean cultivation technologies and the development of a strategy of adaptive crop production intensification, which is based on the use of the adaptive potential of all agroecosystem biological components Babych, 2007; Petrichenko et al., 2006; Petrichenko & Wednesday, 2001, Zhmurko & Jameev, 1999; Babich, 1998). Among Ukrainian commodity producers, the variety continues to be the most effective key factor for intensifying agricultural production. The importance of seed quality is also growing, which largely determines the level of yield and product quality. It is essential that in the biological memory of a seed, which determines its agronomic quality, three main types of biological information play the leading role: genetic, physiological conditions of cultivation, and seed storage conditions (Dutra & Vieira, 2006).

It should be noted that with the rapid growth of soybean sown area, the level of its yield continues to be almost unchanged and on average it is in Ukraine from up to 1.40 t/ha. This indicator is not corresponding with the current requirements. The world level of selection and technology of soybean cultivation should have a positive effect on the oil industry of our country (Ogurtsov, 2008, Babich, 1998). The growth in recent years in the number of abnormal weather phenomena makes demands that are difficult to combine in one variety. In this connection, breeders and technologists are facing one of the main tasks today. It is the breeding and application into the production of varieties with high adaptive potential and level of productivity (Kalenska et al., 2015, Prus et al., 1982) the study aimed to study the influence of weather and climatic conditions (average daily air temperatures and precipitation during the growing season) on the level of soybean yield.

Materials and Methods

The main field researches were carried out in 2004-2020, in the Department of Plant Breeding and Variety Research of the The Plant Production Institute named after V.Ya. Yuriev of NAAS. Soil - deep, slightly leached chernozem with a granular structure. It is characterized by the following agrochemical parameters: humus content (Method for determination of organic matter according to Tyurin) - 5.8%; pH - 5.8; hydrolytic acidity - 3.29 mg/eq. per 100 g of soil. Stocks of nutrients in the control variant without fertilizers: nitrogen - 132 mg/kg, phosphorus - 104 mg/kg, potassium - 128 mg/kg; with backgrounds with the use of mineral fertilizers ($N_{30}P_{30}K_{30}$): nitrogen - 130-140 mg/kg, phosphorus - 180-200 mg/kg, potassium - 170-190 mg/kg of soil.

Results and Discussion

In the conditions of the research area, the main limiting factors are the amount of precipitation and temperature during the growing season of crops and soybeans including. Analysis of the influence of weather and climatic factors on the level of soybean yield was made based on the Pearson correlation coefficients. The level of impact was determined according to the following Table 1 (Mkhitaryan et al., 2018, Rodgers & Nicewander, 1988):

Table 1. Values of Pearson correlation coefficients.

Correlation	negative	positive
No correlation	−0.09-0.0	0.0-0.09
Low correlation	−0.3-0.1	0.1-0.3
Average correlation	−0.5−0.3	0.3-0.5
High correlation	−1.0−0.5	0.5-1.0

Over the years of research, the weather conditions during the growing season of the plants were quite contrasting, that allowed to fully assess the varieties and hybrids (Figure 1). On the average for years of research (2004-2020) the deviation of average daily temperature is plus 2.21 °C. There is a significant difference between months and years. Thus, there is a significant warming in the period August-September, by 2.41-2.21°C, in other months, the increase in air temperature is insignificant – 0.25℃ in April, 0.70 °C in May, 0.40 °C in June and 0.64 °C in July. Significantly greater differences were observed over the years of research. Thus, August-September for all years of research was warmer than long-term indicators by 0.4-7.4℃. Very large diversity of Temperature indicators is observed in the spring and summer. Thus, April was cooler than the optimal values of 5 years out of 17 (in 2004 - by 0.7, in 2007 - by 1.3, in 2009 - by 7.9, in 2011 - by 1.4, and in 2020 - by 1.3 °C).

May was cooler for 6 years and much warmer for 11 years, with an average of + 0.7-4.9°C. The situation is similar in other months. In addition to air temperature, the amount of precipitation during the growing season is essential for the growth and development of plants and the timely passage of phases and as a result for the productivity formation (Figure 2).

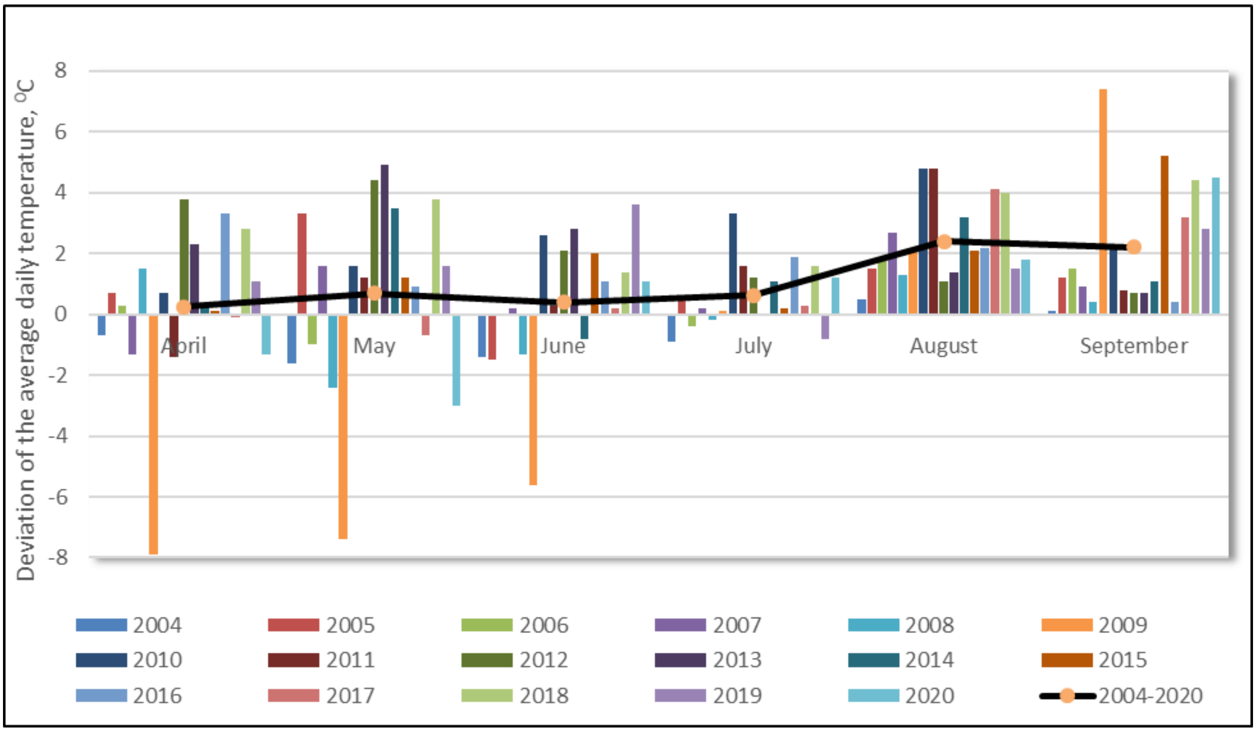

Fig. 1. Deviation of the average daily air temperature from the optimal values, 2004-2020.

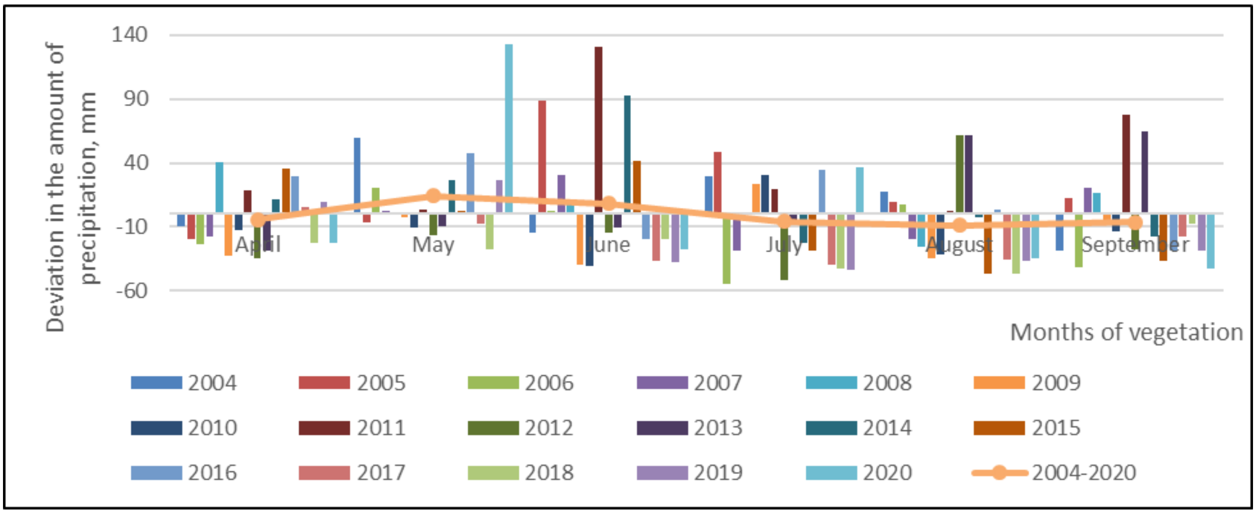

Fig. 2 Deviations in the amount of precipitation in 2004-2020.

Thus, on average over the years of research, the amount of precipitation during the growing season, compared with long-term values was within the normal range – 305.8 mm in 2004-2020 when the optimal values are 304.6 mm. It was noted that a strong variety in their value depends on the year and months. Insufficient moisture was observed in 9 years (from 14.3 mm in 2007 to 168.1 mm in 2018), and the excess - accordingly in 8 years, with fluctuations from 41.1 mm in 2020 to 251.8 mm in 2011

April was with insufficient moisture in 10 years out of 17. A decrease in precipitation was noted, compared with long-term indicates from 9.8 to 34.4 mm. At the same time, 7 years in April were wetter - by 5.5 - 40.2 mm, accordingly. In addition, seven years were less moisturized in May, 8 years – more moisturized - by 20.3-132.4 mm. That is, in recent years it has been observed an increasing lack of precipitation in the sowing and post-sowing periods for spring oilseeds, including soybeans. In other months (June - September) there is a similar regularity - in most years, insufficient rainfall during the growing season, especially in August and September. In addition to the calculations of deviations, linear regressions on average daily temperatures for the period of spring-summer vegetation were calculated. Calculations show a constant and stable increase in average daily temperature for all months. At the same time, it is insignificant in April and sharply increases in the summer months, especially in June. The regression equations for the months are y=0.1301x+8.6757 in April and y=0.1226x+18.566 in June. Based on the analysis of average daily temperature for 10 years and linear regression, we can conclude that this indicator will constantly grow in the future.

Moreover the precipitations of the spring-summer period have a great importance. First of all, it is April and May. Thus, the regression analysis of the amount of precipitation for the research period predicts an increase in this indicator only in these two months (Fig. 3). The regression equations for them have the form y=0.9419x+22.658, and y=1.7973x+41.724 June and July are characterized by heavy rains and the possibility of hail, which negatively affects the soybean yield. According to the equations and regression graphs, these months tend to decrease the amount of precipitation (the equation, accordingly, has the form y=-2.9848x+98.169 and y=-1.799x+82.215. in August - a similar tendency to reduce precipitation, the regression equation has the form y=-2.3203x+58.907.

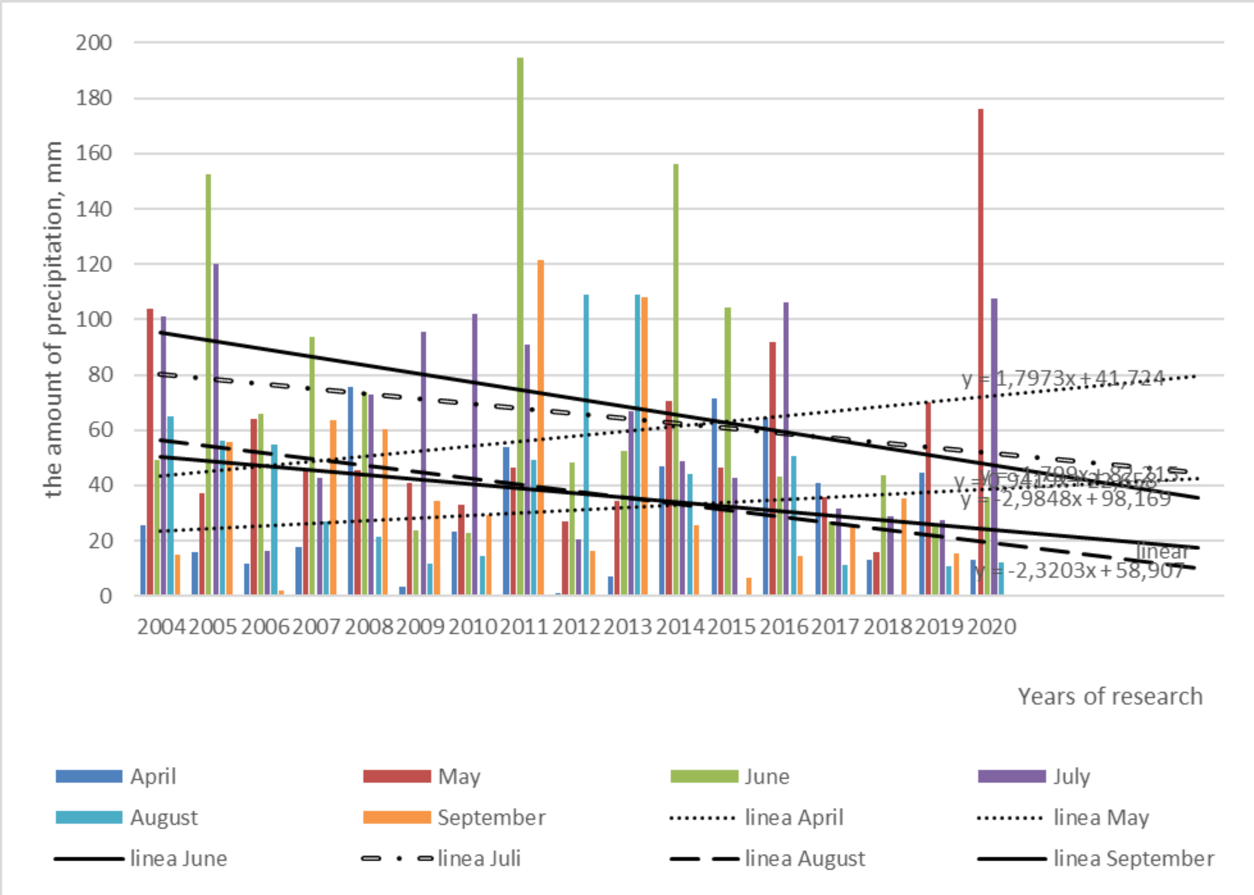

Fig. 3. The amount of precipitation and linear regression for the period of spring-summer vegetation, 2004-2020.

In addition to the amount of precipitation, their distribution by months during the growing season is important. On average, during the years of research (2004-2020), two months had less precipitation compared to long-term values. This is April – 9.5%, when the norm is 11.7%, and July – 20.5 and 23.5%, accordingly. In June, the amount of precipitation was higher than the optimal indicator – 25.4 against 20.8%. In other months, the distribution of precipitation was close to the optimum (Figure 4).

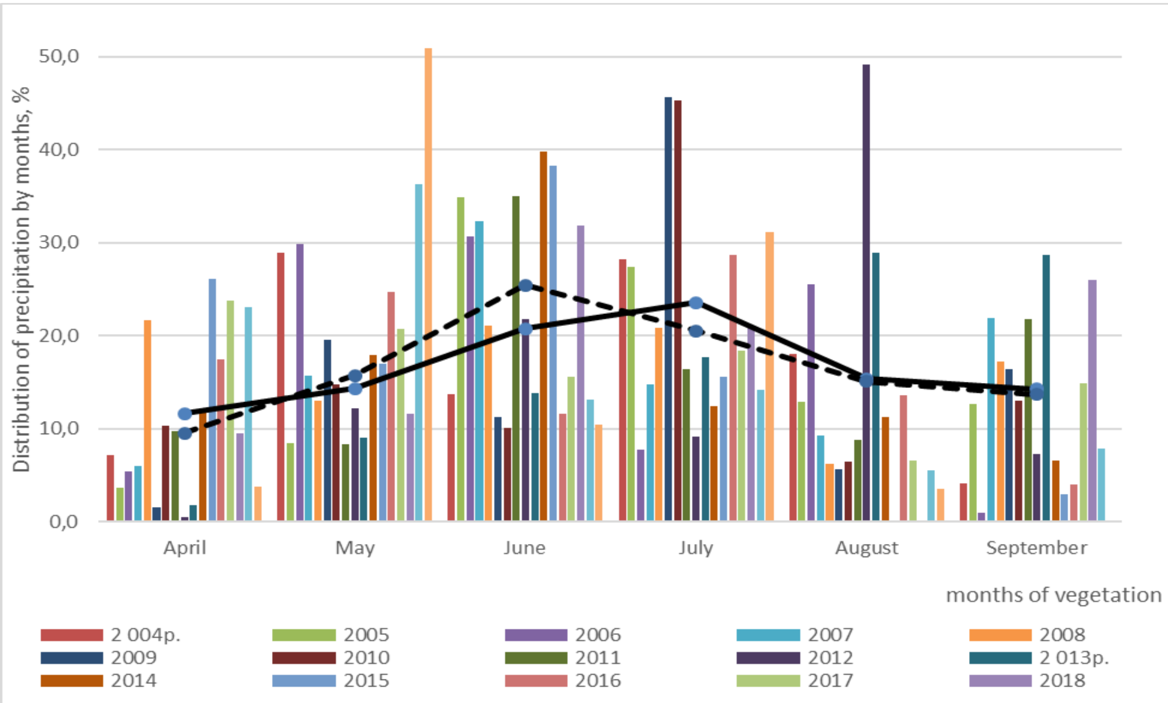

Fig. 4. Distribution of precipitation by month compared to long-term values, %, 2004-2020.

The spring-summer period was also characterized by instability of moisture over the years. Thus, the April was excessively moist (from 17.4 to 26.2%) during 5 years out of 17, and four years was insufficiently moist (from 0.5 to 5.4%, when an optimum is 11.7%). During the research period in May, the amount of precipitation in most years is close to the norm or exceeds it. In June and July, the wet and dry years had a ratio of 7/8 and 5/10, accordingly. And two years can be considered as optimal. It should be noted that exactly during these months the most unproductive precipitation fall in the form of hail and showers.

According to the research results, the greatest influence on the level of productivity of oilseeds and especially soybeans has the weather conditions of the growing season. According to the results of correlation analysis of the weather conditions influence on soybean yield in the period 2004-2020, it was noticed a negative effect of the average daily temperature of August, in the case of applying, before soybean sowing, mineral nutrition $N_{30}P_{30}K_{30}$ and 30 t/ha of manure (correlation coefficient r = -0.428). For other mineral background nutrition – average daily temperature had little effect on the level of crop yield (Table 2).

Table 2. Correlation between soybean yield and weather conditions of the growing season, 2004-2020.

Month	Control varient	Manure, 30 t/ha	(NPK)30 + Manure	(NPK)60 + Manure	Середнє
		The average temperature			
April	-0.028	-0.019	0.004	-0.071	-0.042
May	-0.037	0.002	-0.032	-0.082	-0.038
June	-0.111	-0.084	-0.066	-0.167	-0.123
July	0.117	0.079	0.215	0.082	0.083
August	-0.208	-0.245	-0.428	-0.264	-0.252
September	-0.277	-0.263	-0,.177	-0.198	-0.240
		Precipitation			
April	0.251	0.201	0.064	0.160	0.191
May	0.408	0.292	0.241	0.318	0.319
June	0.278	0.259	-0.045	0.184	0.232
July	0.550	0.501	0.555	0.513	0.514
August	0.205	0.255	0.214	0.216	0.237
September	0.100	0.209	-0.070	0.112	0.140

The amount of precipitation had a slightly greater impact. Thus, on all backgrounds of mineral nutrition, precipitation of July had a positive effect on the culture (r = from 0.501 to 0.555). May precipitation had a positive effect only in the case of growing soybeans in the control (r = 0.408) and in the case of the background of $N_{60}P_{60}K_{60}$ + 30 t/ha of manure (r = 0.318). Slightly different situation we can see analysing these indicators for smaller periods - 5 and 6 years (Table 3). Thus, the negative impact of elevated temperatures in April, in the case of all backgrounds of mineral nutrition, was observed for the period 2004-2008 and 2009-2013 (the correlation coefficient from r = -337 to r = -0.660), and for the period 2014-2020 - on the contrary, it is positive (r = from 0.408 to 0.558).

Elevated temperatures in May for the first period of research, 2004-2008 years had a positive effect on all backgrounds of mineral nutrition (from r = 0.467 to r = 0.566). For the next period of 2009-2013, a negative impact was observed in the variant of using mineral fertilizers under soybean – r = -0.722 and r = -0.470. The average daily air temperatures in June, July, and August for the period 2004-2008 did not affect the crop yield. Their influence in the period 2009-2013 depended on the background of mineral nutrition. Therefore in June - for all nutrition backgrounds, they had a negative value (r = from -0.340 to r = -0.748). July temperatures had a negative effect when soybean cultivation was with the 30 t/ha of manure background and with additional application of $N_{60}P_{60}K_{60}$ (r = -0.450 and r = -0.524), and with the use of $N_{30}P_{30}K_{30}$ – on the contrary – a positive effect (r = 0.345). During the period 2014-2020, June temperatures affected only in the case of the $N_{30}P_{30}K_{30}$ background (r = 0.309), and July temperatures – in the case of all backgrounds (r = from 0.317 to 0.460). Moreover during this period of research there was a strong negative impact of elevated temperatures on soybeans in August and September. Such an impact for earlier periods was not observed. When analyzing the impact of precipitation for the same periods, it was noted that for the last study period (2014-2020), this indicator has a much higher positive impact on crop yields for all months and all backgrounds of mineral nutrition, compared to previous research periods.

Table 3. Correlation between soybean yield and weather conditions of the growing season by period.

Years of research	2004-2008				2009-2013				2014-2020			
Research option	Control variant	Manure, 30 т/га	(NPK)30 + Manure	(NPK)60 + Manure	Control variant	Manure, 30 т/га	(NPK)30 + Manure	(NPK)60 + Manure	Control variant	Manure, 30 т/га	(NPK)30 + г Manure	(NPK)60 + Manure
The average temperature												
April	-0.660	-0.579	-0.598	-0.624	-0.306	-0.337	-0.607	-0.557	0.408	0.513	0.558	0.533
May	0.467	0.566	0.536	0.558	-0.188	-0.211	-0.722	-0.470	-0.143	-0.027	-0.019	-0.030
June	-0.230	-0.233	-0.286	-0.216	-0.340	-0.397	-0.748	-0.649	0.077	0.243	0.309	0.193
July	0.098	0.274	0.162	0.221	-0.248	-0.450	0.345	-0.524	0.460	0.366	0.317	0.425
August	-0.125	-0.022	-0.143	-0.047	0.224	0.046	0.456	-0.044	-0.567	-0.621	-0.610	-0.574
September	-0.428	-0.369	-0.371	-0.356	-0.063	-0.010	0.696	0.279	-0.510	-0.515	-0.493	-0.534
Precipitation												
April	-0.317	-0.256	-0.344	-0.322	0.631	0 .490	-0.818	0.313	0.440	0.413	0.448	0.385
May	0.254	0.064	0.206	0.134	0.744	0.721	0.240	0.712	0.473	0.406	0.337	0.406
June	0.234	0.378	0.328	0.343	0.882	0.808	-0.783	0.618	0.000	-0.061	-0.126	-0.070
July	0.586	0.606	0.648	0.593	0.054	-0.004	0.115	0.041	0.794	0.688	0.635	0.712
August	0.224	0.092	0.274	0.170	-0.006	0.090	-0.696	-0.071	0.649	0.598	0.549	0.623
September	0.290	0.462	0.300	0.380	0.562	0.599	-0.906	0.379	-0.478	-0.418	-0.396	-0.386

Conclusion

On average over the years of research (2004-2020), the deviation in the average daily temperature during the growing season of soybeans is plus 2.21 °C. There is a significant warming during the August-September period, by 2.41-2.21 °C. During other months, there is an insignificant increase in air temperature by 0.25 °C in April, by 0.70 °C in May, by 0.40 °C in June and by 0.64 °C in July. There is a strong diversity in precipitation depending on the year and months. Insufficient moisture was observed in 9 years (from 14.3 mm in 2007 to 168.1 mm in 2018), and the excess – accordingly in 8 years, with fluctuations from 41.1 mm in 2020 to 251.8 mm in 2011. Calculations of linear regression indicate a constant and stable increase in average daily temperature for all months. At the same time, it is insignificant in April and sharply increases in the summer months, especially in June. The regression equations for the months are y=0.1301x+8.6757 in April and y=0.226x+18.566 in June.
Moreover very important are the precipitations of spring and summer. First of all, it is April and May. Thus, the Regression analysis of the amount of precipitation for the research period predicts an increase in this indicator only in April and May. The regression equations are y=0.9419x+22.658 and y=1.7973x+41.724. According to the equations and regression graphs, June and July tend to decrease the precipitation. The equation, accordingly, y=-2.9848x+98.169 and y=-1.799x+82.215, in August – a similar tendency to reduce precipitation, the regression equation has the form y=-2.3203x+58.907.
During the period 2004-2020, the precipitation of July had a positive effect on the crop on all backgrounds of mineral nutrition (r = from 0.501 to 0.555). May precipitation had a positive effect only in the control variant of growing soybean (r = 0.408) and when the background was $N_{60}P_{60}K_{60}$ + 30 t/ha (r = 0.318). When analyzing the impact of precipitation for the same periods, it was noted that for the last research period (2014-2020), this indicator has a much higher positive impact on crop yields for all months and all backgrounds of mineral nutrition, compared to previous research periods.

References

Adamen, F. F. (1999). Nitrogen fixation and the main directions of improving the nitrogen balance of soils. Bulletin of Agricultural Science, 2, 9–16.
Babich, A. O. (1998). Soya for Health and Life on Earth. Agrarna nauka. (in Ukrainian).
Babich, A., Omer, R., Poberezhna, M. (2000). Soybeans and soybean meal in animal feed, poultry and fish. Soybean association. (in Ukrainian).
Babych, A. (2007). Soybean varieties and prospects for its production in Ukraine. Proposal, 4, 46–49.
Climate change has led to a 0.9% reduction in world wheat yields, scientists say. (2019). SuperAgronom.Com. Home Site For Agronomists. Available from: https://superagronom.com/news/7899-zmina-klimatu-sprovokuvala-skorochennya-svitovih-vrojayiv-pshenitsi-na-09--vcheni. (in Ukrainian).
Dutra, A. S., & Vieira, R. D. (2006). Accelerated ageing test to evaluate seed vigor in pumpkin and zucchini seeds. Seed Science and Technology, 34, 209–214.

Gortlevsky, A.A. (1998). Recommendations for regulating the growth of roslin in the agricultural sector of Ukraine. Regulators of the Growth of Roslin in Agriculture, 93–143.
Kalenska, S.M., Ermakova, L.M., Palamarchuk, V.D., Polishchuk, I.S., & Polishchuk, M.I. (2015). System of modern intensive technologies in crop production. Kyiv. Rogalska I.O. (in Ukrainian).
Mkhitaryan, V. S., Arkhipova, M. Y., Mironkina, Y. N., Sirotin, V. P., & Dubrova, T. A. (2018). Data analysis. Yurayt Publishing House. (in Russian).
Ogurtsov, E. M. (2008). Soybeans in the eastern Forest-Steppe of Ukraine. KhNAU named after V.V. Dokuchaiv. (in Ukrainian).
Osipchuk, A. M., Chernyak, N. G., Honcharuk, O. P. (2018). Recommendations for the development of soya in the state donations of Kiev. Institute of Animal Breeding and Genetics nd. a. M.V.Zubets of National Academy of Agrarian Science of Ukraine (in Ukrainian)
Petrichenko, V. F., Sich, A. O., Ivanyuk, S. W., Kolisnyk, S. I. (2006). Influence of agroclimatic factors on soybean productivity. Bulletin of Agrarian Science, 2, 19–23.
Petrichenko, V. F., Wednesday, L. M. (2001). Scientific base of soybean harvest formation in early terms of sowing in the conditions of the Forest-steppe of Ukraine. Coll. Science. Proceedings of the Vinnytsia State Agricultural Institute, 9, 53.
Prus, A. V., Sichkar, V. I., & Kolot, V. N. (1982). Soybean is a universal crop . Harvest. (in Russian).
Rodgers, J. L., & Nicewander, W. A. (1988). Thirteen Ways to Look at the Correlation Coefficient. The American Statistician, 42(1), 59–66.
Shashkov, E.A., Tanchik, S.P., Pavlov, O.S. (2018). Water consumption and productivity of soybeans depending on the width of the rows and the standing density in the right-bank forest-steppe of Ukraine. Scientific Bulletin of the National University of Life and Environmental Sciences of Ukraine. Series: Agronomy., 294, 83–89.
Skazkin, F.D. (1961). Critical period for insufficient water supply. Publishing house of the Academy of Sciences of the USSR. (in Russian).
Soybean growing technology. (2020). Available from: http://proseed.com.ua/techno.html
The change in the global climate has led to a decrease in crop yields. (2011). Voice of America. Available from: https://www.golosameriki.com/a/corn-fields-2011-05-11-121630859/234441.html
Tsilyurik O. (2019). Soil tillage: important nuances. Agribusiness Today. Available from: http://agro-business.com.ua/agro/mekhanizatsiia-apk/item/13934-obrobitok-gruntu-pid-soiu-vazhlyvi-niuansy.html (in Ukrainian).
Valkov, V. F. (1986). Soil ecology of agricultural plants. Moscow. Agropromizdat (in Russian).
Zhmurko, V. V., Jameev, V. Y. (1999). Dehydrogenase activity and the content of soluble protein in the roots of soybean seedlings (Glicine Max. L.) in the conditions of optimal and low temperatures. Physiology and Biochemistry Cult. Plants, 4(31), 308–313.

Citation:
Tsekhmeistruk Mikolai, Pankova Oksana, Kolomatska Valeriia, Kobyzieva Liubov, Artiomov Mikolai, Sirovitskiy Kirill. (2021). Influence of weather and climatic conditions on soybean yield. *Ukrainian Journal of Ecology, 11* (4), 11-17.