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N. Sh. Suleimenova[1], D. B. Kalykov[1], M. Filipova[2], G. Orynbasarova[1]

[1]Kazakh National Agrarian University, Almaty, Kazakhstan;
[2]Angel Kanchev University of Ruse, Bulgaria.
E-mail: naziya44@gmail.com, 2773477@mail.ru, gulnar.86_27@mail.ru

CLIMATE CHANGE AND ESCALATION OF AGROECOSYSTEM'S ECOLOGICAL PROBLEMS

Abstract. In this article, in the "climate - agriculture" system, we have formed research tasks: - one of them is related to the assessment of changes in climate parameters, - the second, the impact of changes in climate parameters on the environmental situation of the agro ecosystem and development of ways to adapt the technology of oilseed cultivation to changing climatic conditions in the South-East of Kazakhstan. Experimental results are given, on the basis of 12-year research, the impact of changes in climate parameters on productivity is estimated for the first time, and the aggravation of environmental problems of the agro ecosystem and the possibility of solving the problem of adaptation to high climate changes in the South-East of Kazakhstan are revealed. The scientific basis for improving the environmental situation of soybean and rapeseed agro phytocenosis is established, depending on the use of soil-protective technologies for oilseeds cultivation, which mitigate the risk of drought in years with a high increase in air temperature. The effectiveness of the use of soil protection methods of soil treatment with resource-saving technology of cultivation of oilseeds in the agricultural ecosystem is revealed. The regularity of positive changes the soil fertility of the arable soil layer as a result of the use of soil protection minimal technology (Mini-till) which provides an increase in the quality of the soil resource and the restoration of agro physical factors of soil fertility. Under crops of cultivated plants the ecological situation of plant growths and development of crops and significantly increases the productivity of soy and rapeseed.

Key words: climate, natural resource, climate change, risk, agriculture, adaptation, technology.

Introduction At the present stage, due to the ongoing technogenic and anthropogenic changes taking into account climate change, environmental science has acquired a purely applied character [1]. Agriculture is the main area from which anthropogenic impacts originate. Since it is the only sector of the economy that carries the greatest burden on the environment, it requires determination of agricultural sector's development principles based on adaptation measures to climate change associated with direct usage of land, plant and energy resources of agro ecosystem [2].

In accordance with established climatologists (Ivanova, Kiryushina, 2009 and Schwartz et al., 2001), the most important climate-related events at the present stage is so-called global warming, which has been especially pronounced since the late 80s of the XX century [3, 4]. This event had put forward the problem of global changes in environment under the influence of climate change among ecology's fundamental problems along with the applied nature. Therefore, the risks of agro ecosystem for world agriculture stand out as the most significant in the list of potential environmental problems associated with global warming [5].

However, it is difficult to estimate the extent to which individual countries will be affected. For this reason, a study was undertaken (Cline, 2007) in order to obtain a more accurate long-term assessment of the consequences. Based on current problem, it is necessary to determine the likely impact on the efficiency of agricultural production development in a certain country and regions [6,7].

In the last decade of the XXI century, the *problems of climate change on the planet* are increasingly being discussed (Gruza, Rankova 2003., Bautin 2011) since this factor significantly affects the formation of agricultural crops [8,9].

In a discussion at national communication of the Republic of Kazakhstan on the UN Framework Convention on Climate Change, published in 2013, experts came to conclusion that over the past 70 years, an increase in average annual and seasonal surface air temperatures has been observed throughout Kazakhstan [10].

Thus, our summarized hypotheses of climate change are quite high, due to the large uncertainty of natural changes in the specific conditions of the agro ecosystem of the South-East of Kazakhstan. Along with the complexity, ambiguity and insufficiency of scientific developments in these conditions, it is difficult to solve fundamental problems of theoretical and practical significance in the field of ecology [11,12,13]. In this regard, the solution of agro ecological problems at the present stage due to the ongoing anthropogenic and anthropogenic changes in the global climate change is a very urgent problem. Therefore, there is a need to assess the possible consequences of climate change in the specific conditions of the agro-industrial complex of the South-East of Kazakhstan and to develop measures to adapt the technology of cultivated crops to changing climate conditions.

Therefore, to achieve the goal of our research in the "climate - agriculture" system, we have formed research tasks: - one of them is related to the assessment of changes in climate parameters, - the second, the impact of changes in climate parameters on the environmental situation of the agro ecosystem and ways to adapt the technology of oilseed cultivation to changing climatic conditions in the South-East of Kazakhstan.

This article presents experimental results based on 12-year research, the impact of changes in climate parameters on productivity is estimated for the first time and the aggravation of environmental problems of the agro ecosystem and the possibility of solving the problem of adaptation to high climate changes in the South-East of Kazakhstan is revealed. The scientific basis for improving the environmental situation of soybean and rapeseed agrophytocenosis is established, depending on the use of soil-protective technologies for oilseeds cultivation, which mitigate the risk of drought in years with a high increase in air temperature. The effectiveness of the use of soil protection methods of soil treatment with resource-saving technology of cultivation of oilseeds in the agricultural ecosystem is revealed. The regularity of positive changes the soil fertility of the arable soil layer as a result of the use of soil protection minimal technology which provides an increase in the quality of the soil resource and the restoration of agrophysical factors of soil fertility. Under crops of cultivated plants, the ecological situation of plant growth and development is optimized and productivity is significantly increased.

Methods and objects of research. Experiments were carried out on the territory of educational and experimental farm "AgroUniversity" of the Kazakh National Agrarian University, located on foothill plain of the North ern slope of Ili Alatau. Soils distribution and formation of climate features in the region are subject to the law of vertical zonality (Saparov, 2014.), which is most clearly expressed in the central part of the Northern Tien Shan. Absolute marks of territory elevation 550-700 m above sea level. The research area is characterized by a sharply continental climate, low air humidity, abundance of sunlight, short but moderately cold winters [14]. The average annual precipitation is 540 mm. About 300 mm of precipitation falls during the warm season. The average annual air temperature ranges from 7.7-8.1^{0}C.

Field experiments were made on meadow-chestnut soils of heavy mechanical composition. Chemical composition of meadow chestnut soil is characterized by a moderate humus content (Eleshev, 2014). The following regularity should be noted in distribution of humus along the profile: its relatively high content (4.40-4.45%) in the upper horizon sharply, decreases more than 2-times upon transition to the next sub-till horizon [15]. The meadow-chestnut soil by its water-physical properties and the level of potential fertility fully satisfies the conditions of cultivation of all types of crops, including oilseeds.

The objects of research were soy of Eureka variety and spring rape of Maily sort. The experimental studies were made by generally accepted classical methods: experiment- test and observation, one-factor and multifactor field experiments (Kiryushin et al, 2009; Ivanov, 2008 and All-Russian Research Institute of Feed named after V.R. Williams, 2011). The main research method was field experiment, accompanied by numerous observations, counts and laboratory analyzes. Field experiments were established using the experimental methodology (Novikov, 2010), as well as the “Methodology for conducting field agrotechnical experiments with oilseeds” (Lukomets, 2007).

Results of the research and discussions. To estimate the parameters of climate change, used data were obtained on the basis of the implementation of 6 scientific grant projects for the Ministry of Agriculture of the Republic of Kazakhstan and the Ministry of Education and Science of the Republic of

Kazakhstan for 2006-2017 meteorological data of the Kazakh Meteorological Service and agricultural statistics of the Almaty region.

Many forecasts highlight the negative effects of global change on agriculture. A significant change in weather conditions for agricultural production in study areas is noted, which is associated not only with an increase in temperature, but also with the fact that the climate is becoming drier.

We have studied climate change and its impact on agricultural goods productivity in conditions of southeast Kazakhstan in the "climate - agriculture" system. Two aspects have been distinguished: “climate as a natural resource” and “climate change as a risk for agricultural production”. The average annual air temperature during the years of research exceeds the long-term average value and varies between 8.8 °C and 11.7°C with an average long-term value of the year temperature of 7.7 °C. The results obtained show distribution of air temperature by months in years of research and indicate climate warming (table 1).

Table 1 – Distribution of air temperature by months in years of research (2006-2017), t^0C

Research years	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	Annual
Average yearly air temperature, t^0C													
2006	-6,4	-1,7	-7.5	13,3	17,4	22,4	24,0	24,6	17,7	13,4	5,5	-6,7	11,2
2007	-3,7	0,4	3,5	14,4	17,4	22,9	24,6	23,4	19,6	8,3	5,2	-5,9	10,8
2008	-10,4	-4,2	9,1	10,	20,4	24,8	25,8	25,2	18,1	10,7	3,8	-4,2	10,8
2009	-3,3	-2,2	4,9	9,7	14,8	19,6	22,6	21,2	15,4	10,2	1,2	-2,8	9,3
2010	- 2,5	-5,9	2,9	10,8	14,7	20,3	22,1	22	16,3	10,9	4,8	-2,7	9,5
2011	-9,8	-3,7	0,3	12,9	16,3	21,3	22,7	22,3	17,8	9,9	1,3	-6,1	8,8
2012	-10,2	-6,0	2,0	15,6	18,6	23,5	23,7	23,4	23,3	11,6	0,1	-13,6	9,3
2013	-9,6	-8,8	3,8	12,3	16,9	21,3	24,9	23,0	19,9	13,4	3,7	-3,5	9,8
2014	-4,3	-13,6	3,6	10,1	18,6	23,0	24,5	24,1	18,0	9,4	0,9	-3,3	9,2
2015	-2,5	+1,1	4,5	13,5	18,8	22,6	27,3	25,5	19,8	10,5	1,2	4,8	11,4
2016	0,2	0,0	9,1	13,4	16,6	23,1	23,7	22,9	20,3	9,6	1,1	-4,4	10,3
2017	-2,8	1,8	10,6	14,1	19,2	24,8	25,5	23,8	20,8	9,7	2,1	- 6,9	11,7
Ave. air t^0C	-10,8	-8,5	0,7	10,4	16,4	21,2	24,1	22,1	16,0	8,3	-0,9	-7,6	7,7

Thus, during the years of research, the anomaly of average annual temperature in south-east of Kazakhstan reaches 3°C and 4°C. The average annual air temperature shows rapid climate warming in scope of our research and it is noticeably greater than global climate change of the whole globe, where the change in air temperature by many sources on average is 1°C.

The study site has shown that almost one third of annual precipitation falls in spring (April-May). The number of days with precipitation in these months reaches 10-14. On dry days, the temperature rises sharply. However, despite increased temperature background, due to frequent rains, the hydrothermal coefficient in spring is quite high and amounts to 2.0-3.8, the value of which characterizes high seasonal rainfall in the region. In parallel with a large amount of precipitation, the maximum air temperature reaches up to 30 °C and 35 °C. The obtained results of climate change proves the general tendency of sharp climate change and can be characterized as “warming with increasing aridity” in scope of our research. To illustrate climate change, we proposed a four-dimensional gradation of climate change over 12 years of study, with increasing air temperature through 1°C, as in the whole world (table 2).

Table 2 – Climate changes by air temperature in conditions of southeast Kazakhstan (for 2006-2017)

# of gradation	Change of average daily air temperature, drought	Research years	Amount of years with t °C change
1st	t °C rise by1°C	Air temperature change exceded 1 °C during all research years	
2nd	T °C rise by 1,1-2,0°C	2009, 2010, 2011, 2012 and 2014	5 years out of 12
3rd	T °C rise by 2,1-3,0°C	2013 and 2016	2 years out of12
4th	T °C rise by 3,1-4,0°C	2006, 2007, 2008, 2015, 2017	5 years out of12

According to the results of accepted gradation, the following was revealed: By the first gradation, the change in average, daily air temperature in all years of research did not exceed 1 °C. There was not a single year when temperature exceed the typical long-term average air temperature of the research area (t = 7.7 °C), which proves the reliability of global climate change in conditions of our research in southeast Kazakhstan.

The second gradation includes years 2009, 2010, 2011, 2012, 2014 of research with an increase in air temperature from 1.1 °C to 2.0 °C. Climate change refers to the third gradation: 2 years out of 12 years - these are 2013 and 2016 with an increase in the average daily air temperature from 2.1 °C to 3.0 °C. The fourth gradation has climate change, which includes the largest anomalous number of years - 5 of 12 years - these are 2006, 2007, 2008, 2015 and 2017 with an increase in the average daily air temperature from 3.1 °C to 4.0 °C. The obtained results of climate change justification prove general and rapid tendency of climate change, where "warming with increasing aridity" was revealed, out of the 12 years examined, arid were 8 - these are 2006, 2007, 2008, 2009, 2014, 2015, 2016 and 2017.

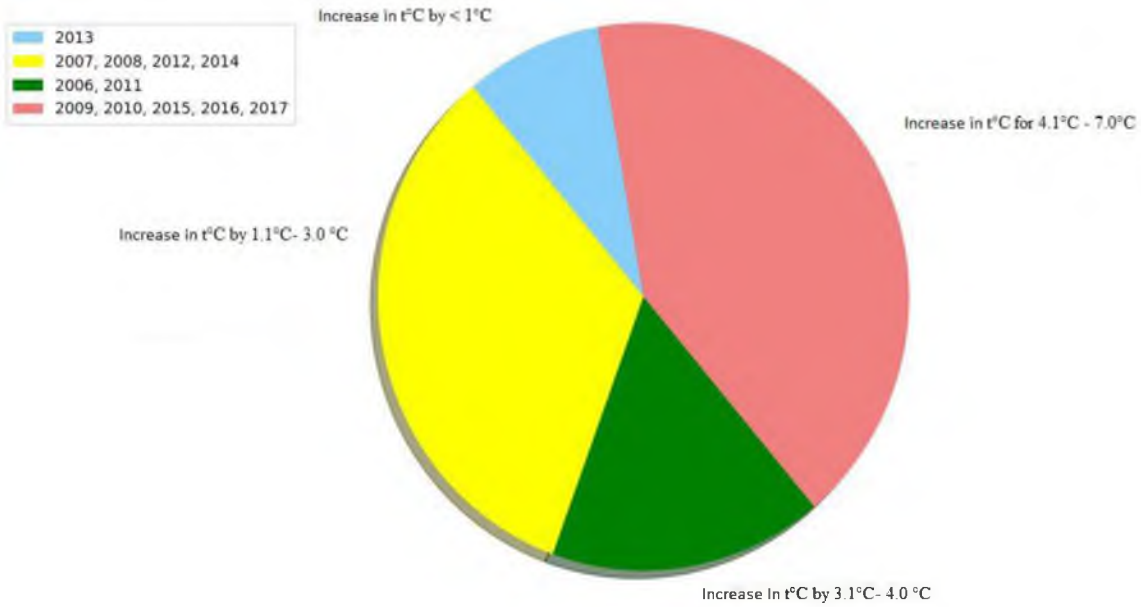
Thus, during the years of study in south-east of Kazakhstan, the change in average daily air temperature was at risk and was characterized by an anomalous average annual temperature. In all years of our 12-year survey, the air temperature was higher than the average long-term level of warming, of which 4 years the temperature exceeded the norm from 1.5 and 1.8 °C and 8 years - from 2.1 °C to 4 °C, which indicates an abnormal situation and have high risk of oilseed cultivation in the agricultural zone of southeast Kazakhstan (table 3).

Table 3 – Climatic changes by parameters of air temperature during winter periods in years of research, t ° C

Research years	Winter air temperature by months			Average daily t^0C during winter period	t^0C changes in comparisson with multiple-year data
	December	January	February		
2006	-6,7	-6,4	-1,7	- 4,9	+ 4,1
2007	-6,7	-3,7	0,4	-7,9	+ 1,1
2008	-5,9	-10,4	-4,2	-6,7	+ 2,3
2009	-4,2	-3,3	-2,2	-3,6	+ 5,4
2010	-2,8	- 2,5	-5,9	-3,7	+5,3
2011	-2,7	-9,8	-3,7	-5,4	+ 3,6
2012	-6,1	-10,2	-6,0	-7,4	+ 1,6
2013	-13,6	-9,6	-8,8	-10,7	Cold winter
2014	-3,5	-4,3	-13,6	-7,1	+ 1,9
2015	-3,3	-2,5	+1,1	-1,6	+ 7,4
2016	4,8	0,2	0,0	-1,7	+ 7,3
2017	-4,4	-2,8	1,8	-1,8	+ 6,2
Average winter t^0C over multiple years	-7,6	-10,8	-8,5	- 9,0	

While justify the "climate-agriculture system", we have revealed that climate as a natural resource (average annual air temperature) undergoes a sharp change in all years of research. Along with this, the widespread occurrence of abnormally warm winters was established. During the years of research, a pattern of changes in air temperature over the winter period was revealed. The consequences of climate change are felt in our country more clearly based on the data of the average daily air temperature, especially during the winter period. Since the beginning of the XXI century (2006), there has been a sharp increase in the t0c of air in the winter months. For example, in the month of December, the average daily air temperature in the years of the study increases from -7.6 °C (Wed. mn. years.data) to -2.7 °C, and in some years the air temperature is characterized by a plus value, the average monthly temperature of the air warms up to an average of + 4.8 °C. In the years of research (2006-2017), the average daily t°C of air for the winter period increased to 7.4 °C and 1.6 °C with a typical-characteristic value of the average daily air temperature, which is equal to = 9.0 °C.

During the years of our research, the parameters of air temperatures in the winter period had changed, in December for all years of study air temperatures decreased from -2.7 °C to -6.7 °C, in January air temperature dropped from - 10.4 °C to +0.2 °C and in February air temperature dropped from - 8.8 °C to +1.8 °C (with an average annual temperature of - 7.6 °C), except for one year 2013 (figure).



Climatic changes in parameters of air temperature during winter periods of research years, t°C

In January, an increase in winter air temperature caused a decrease in snow cover. For February, 6 out of 12 research years were characterized by an abnormally elevated temperature values, especially years 2006 (-1.7 °C), 2007 (0.4 °C), 2015 (+ 1.1 °C), 2016 (0 °C), and 2017 (-1.8 °C). Based on the results of our study, it was revealed that warming of winter season conditions accelerated, the average daily temperature during winter months' season increased from 1.1 ° C to 7.4 ° C and is characterized by frequent thaws.

The frequency of abnormally warm winters in conditions of Almaty region increased to 50% in years of research. The climate is also characterized by increased repeatability, abnormally summer drought occurrence rose up to 67%. At the same time, risky climate change environment and the influence of accelerated changes in climate parameters over 12 years is becoming very dangerous, associated with a sharp decrease in crop yields. Thus, the current state of climate change may lead the southeast agricultural region to face completely unforeseen and severe restrictions in form of increased aridity of territories, which will lead to instability of agricultural sector of the Almaty region. The increase in probability of low yields as a result of an increase in frequency of warming in winter and the recurence of drought during warm period over the years of research can be dangerous.

Therefore, adaptation of oilseed cultivation technology to climate change is an important principle in development of the agricultural sector in these new conditions. To make the agricultural sector of Almaty region sustainable, we studied measures to combat drought: - methods of soil protection technologies, such as minimizing the technogenic impact of soil cultivation system and their effect on productivity of oilseeds.

While studying the influence of soil-protective technology methods for oilseeds cultivation, we found that productivity is directly dependent on climate change. Oilseeds in less arid 2016, where air temperature changes were within the range of t - for soybean sowing -1.40 °C and for sowing rapeseed 1.1 °C, with the traditional technology of soybean cultivation are respectively 25.8 c/ha and with rapeseed 16,3 c/ha.

Based on the obtained results, the effectiveness of soil-protective techniques for cultivation of soy and rapeseed was determined depending on influence of emerging climatic conditions.

The effectiveness of the use of soil protection methods of soil treatment with resource-saving technology of oilseeds cultivation in the agricultural ecosystem was revealed. The regularity of positive changes in the soil fertility of the arable soil layer as a result of the use of soil protection minimal technology (Mini-till), which provides an increase in the quality of the soil resource and the restoration of agrophysical factors of soil fertility [22].

Under crops of cultivated plants, the ecological situation of plant growth and development is optimized and productivity is significantly increased (table 4).

Table 4 – Oilseed productivity depending on changes in air temperature, t°C with soil-protective soil cultivation technology (in research years 2015-2017)

Technology		Research years	For soy cultivation			For rape cultivation		
			Ave. daily t°C over vegetation	Air t°C change comparing to multiple year t°C	Yield, c/ha	Ave. daily t°C over vegetation	Air t°C change comparing to multiple year t°C	Yield, c/ha
Traditiona technology – Tillage for depth of 20-22 cm		2015	22,8	+ 2,9	23,9	21,5	+ 2,7	14,7
		2016	21,3	+ 1,4	25,8	19,9	+ 1,1	16,3
		2017	22,8	+ 2,9	24,5	21,5	+ 2,7	14,1
		average	19,9		24,7	18,8		15,0
Resource-saving	Flat-cut 16-18 cm + herbicide	2015	22,8	*+ 2,9*	*29,1*	21,5	*+ 2,7*	*21,3*
		2016	21,3	*+ 1,4*	*27,7*	19,9	*+ 1,1*	*20,6*
		2017	22,8	+ 2,9	28,9	21,5	+ 2,7	19,7
		average	19,9		28,6	18,8		20,5
	Flat-cut 12-14 cm + impulse	2015	22,8	+ 2,9	27,5	21,5	+ 2,7	19,7
		2016	21,3	+ 1,4	27,6	19,9	+ 1,1	18,9
		2017	22,8	+ 2,9	28,2	21,5	+ 2,7	19,4
		average	19,9		27,8	18,8		19,3

With soil-protective resource- saving technology of cultivation during research years, the yield of soy and rapeseed was higher, 27.7 kg / ha and 20.6 kg / ha respectively. The same trend was revealed in drier years of 2015 and 2017, with increase in air temperature - by 2.90 ° C and 2.70 ° C, which had a depressing effect on crop productivity, with yields reduced for soybeans to 23.9-24.5 kg / ha, and for rapeseed up to 14.1-14.7 kg / ha with traditional technology. After applying soil-protective soil cultivation technology, soybean productivity rose from 23.9 c / ha to 29.1 c / ha and rapeseed - from 14.1 c / ha to 21.3 c / ha.

Thus, in case of soil-protective treatment of soybean and rapeseed oilseed cultivation technologies in dry years (2015, 2017), the prevailing optimal conditions for growth and development of crop reduce inhibitory effects of climate change and provide an increase for soybean yield up to 28.9-29.1 c / ha (on average by 23.8%) and for rapeseed to 19.1-21.3 kg / ha (on average by 34.5%) with a change in average daily temperature of the vegetation period at sowing soy by 2.9 °C and by 2.7 ° C for sowing rapeseed. The results obtained indicate the adaptation of cultivated conditions of studied crops to this global climate change and agroecosystem's environment of southeast Kazakhstan.

Conclusion. At the present stage, in south-east of Kazakhstan, as well as throughout the world, the most problematic events related to climate are global warming, changes in climatic parameters, aggravation of agroecosystems' ecological situation, which mark these environmental problems as a risk for agricultural production. It was established that the average annual air temperature exceeds the average-summer value and varies between 8.80 °C and 11.7 °C with an average multi-year temperature of 7.70 °C. In a 12-year study, changes in air temperature were higher than the global average long-term level of warming, of which during 4 years the temperature exceeded norm values from 1.5 to 2.0 °C and during 8 years - from 2.1 °C to 4 °C, which indicates an abnormal situation and high risk for oilseeds cultivation in agricultural zone of southeast Kazakhstan.

The average annual air temperature in some years increases from 3.5 °C to 4 °C in comparison with the average long-term air temperature. 8 years out of studied 12 years were the driest. The results obtained substantiating climate change prove general and rapid tendency of climate change, where "warming with increasing aridity" was revealed. It was revealed that warming of winter conditions accelerated, the average daily air temperature in winter months increased from 1.1 °C to 7.4 °C and is characterized by frequent thaws. The frequency of abnormally warm winters in Almaty region conditions increased to 50% and abnormally summer drought to 67%. Such a climate change and the impact of accelerated changes in climate parameters just in 12 years of study poses unambiguous risk to environment.

In such new risky conditions, adaptation of studied crops' cultivation technology to climate change is an important and only principle for developing agricultural sector in south eastern Kazakhstan. The effectiveness of soil-protective methods of oilseed cultivation technology was determined and the pattern of a positive change in composition of soil's arable layer as a result of using soil-protective minimal technology (Mini-till), which provides increase in soil quality indicators and restoration of soil fertility's agrophysical factors was revealed. Soil-protective methods of soil treatment optimize agro ecosystem's ecological situation, especially in dry years, where optimal conditions for growth, crop development are created, depressing effects of climate change and soybean productivity are reduced to 28.9-29.1 kg / ha (an average of 23.8%) and rapeseed up to 19.1-21.3 kg / ha (average 34.5%). The obtained results indicate adaptation of studied crops' cultivation conditions to climate change and to the environment of southeast Kazakhstan's agro ecosystem.

Н. Ш. Сулейменова[1], Д. В. Калыков[1], М. Филипова[2], Г. Орынбасарова[1]

[1]Қазақ ұлттық аграрлық университеті, Алматы, Қазақстан;
[2]Ангел Кынчев атындағы Русе университеті, Русе, Болгария

КЛИМАТ ӨЗГЕРІСІ ЖӘНЕ АГРОЭКОЖҮЙЕНІҢ ЭКОЛОГИЯЛЫҚ МӘСЕЛЕЛЕРІНІҢ ШИЕЛЕНІСУІ

Аннотация. Мақалада зерттеу мақсатына қол жеткізу үшін зерттеудің екі бағыты қарастырылды: біріншісі, климаттық параметрлердің өзгеру әсерін бағалауға байланысты, екіншісі, агроэкожүйенің экологиялық мәселелерінің шиеленісуі мен климаттың өзгеруіне бейімделу мәселесін шешу мүмкіндігі. 12 жылдық зерттеудегі қол жеткізген эксперименттік мәліметтерге байланысты алғаш рет Қазақстанның Оңтүстік-шығыс жағдайында климаттың өзгеру параметрлерінің өнімге әсері бағаланып, агроэкожүйенің экологиялық мәселелерінің шиеленісуіне байланысты экожүйенің климаттың қарқынды өзгерісіне бейімделу мәселесін шешу мүмкіндігі анықталды.

Ауылшаруашылығын климаттық өзгерістерге бейімдеу және аграрлық өндірістің тұрақтылығын арттыру барысында топырақ қорғау технологиялары, топыраққа техногенді әсерді азайту және ресурс үнемдеуші технология тәсілдерінің майлы дақыл өнімділігіне әсері, құрғақшылыққа қарсы күрес жөніндегі шаралар зерттелді. Алынған нәтижелер негізінде зерттеу жылдарында қалыптасқан климаттық жағдайлардың әсеріне байланысты майбұршақ пен рапс дақылын өсіру технологиясының, топырақ қорғау тәсілдерінің оңтайлы тиімділігі анықталды.

Ауа температурасы жоғары болған жылдары құрғақшылық қаупін жеңілдететін майлы дақылдарды өсірудің топырақ қорғау технологиясын қолдануға байланысты майбұршақ пен рапс агрофитоценоздарының экологиялық жағдайын жақсартудың ғылыми негіздері белгіленді. Климат өзгерісі туралы мәліметтер негізінде климат өзгерісінің жалпы және күрт үрдісі анықталып, әсіресе, жазгы кезеңде «жоғары дәрежелі жылынуда құрғақшылық арта түсетіндігі» байқалды. Қысқы мезгілде климаттық жылылықтың үдей түсуі айқындалып, қысқы айлардың орташа тәуліктік ауа температурасы 1,1 °С-дан 7,4 °С-га дейін көтеріліп, жиі жылынатын кезеңдер сипатталды. Алматы облысы жағдайында қыстық кезеңде аномалды жылыну өзгерістерінің қайталануы 50%-га дейін және жазгы кезеңде аномалды құрғақшылық 67%-га дейін артатындығы дәлелденді. Ауылшаруашылығы экожүйесінде майлы дақылдарды өсірудің ресурс үнемдейтін технологиясы арқылы топырақ қорғау тәсілін қолданудың тиімділігі анықталды. Топырақты қорғау (Mini-till) технологиясын пайдалану нәтижесінде топырақ құнарлығы ресурстары мен топырақтың агрофизикалық факторлары қалпына келтіруді қамтамасыз ету жағдайы негізделіп, топырақтың жыртылған қабатының құнарлығының оңтайлы өзгеру заңдылықтары анықталды. Бұл заңдылыққа байланысты егістегі дақылдардың өсуі мен дамуының экологиялық жағдайы оңтайланып, майбұршақ пен рапс дақылының өнімділігі артады.

Түйін сөздер: климат, табиги ресурстар, климаттың өзгеруі, қауіп, ауылшаруашылығы, бейімделу, технология.

Н. Ш. Сулейменова[1], Д. Б. Калыков[1], М. Флипова[2], Г. Орынбасарова[1]

[1]Казахский национальный аграрный университет, Алматы, Казахстан;
[2]Русенский университет им. Ангела Кынчева, Русе, Болгария

ИЗМЕНЕНИЕ КЛИМАТА И ОБОСТРЕНИЕ ЭКОЛОГИЧЕСКИХ ПРОБЛЕМ АГРОЭКОСИСТЕМЫ

Аннотация. В данной статье для достижения цели исследований сформировано два направления исследования: - одно связано с оценкой влияния изменений климатических параметров; - второе – с обострением экологических проблем агроэкосистемы и возможностью решения проблемы адаптации к изменениям климата. Даны *экспериментальные результаты, на основе 12-летних исследований,* впервые дана оценка влияния изменений климатических параметров на продуктивность, выявлено обострение экологических проблем агроэкосистемы и возможность решения проблемы адаптации к высоким изменениям климата в условиях юго-востока Казахстана.

Для адаптации сельского хозяйства к климатическим изменениям и повышению устойчивости аграрного производства среди целесообразных мероприятий изучены меры по борьбе с засухой: - почвозащитные технологии, - минимизация техногенного воздействия на почвы и влияние приемов ресурсосберегающей технологии на продуктивность масличных культур. На основе полученных результатов определена положительная эффективность почвозащитных приемов технологии возделывания сои и рапса в зависимости от влияния складывающихся климатических условий в годы исследования.

Установлены научные основы улучшения экологической обстановки агрофитоценоза сои и рапса в зависимости от применения почвозащитных технологий возделывания масличных культур, которые смягчают риск засухи в годы с высоким повышением температуры воздуха. Обоснование изменения климата доказывает общую и резкую тенденцию изменения климата, где выявлено «потепление с усилением засушливости» в летний период. Выявлено, что потепление зимних условий ускорилось, среднесуточная температура воздуха зимних месяцев повысилась от 1,1 до 7,4°С и характеризуется частыми оттепелями. Участилась повторяемость аномально теплых зим в условиях Алматинской области до 50% и аномально летней засухи до 67%. *Выявлена эффективность п*рименения почвозащитных методов обработки почвы при ресурсосберегающей технологии возделывания масличных культур в сельскохозяйственной экосистеме. Установлена закономерность положительных изменений плодородия почвы пахотного слоя почвы в результате использования почвозащитной минимальной технологии (Mini-till), обеспечивающей повышение плодородия почвенного ресурса и восстановление агрофизических факторов почвы. Под посевы культивируемых растений оптимизируется экологическая обстановка роста и развития культур и значительно повышается продуктивность сои и рапса.

Ключевые слова: климат, природный ресурс, изменение климата, риск, сельское хозяйство, адаптация, технология.

Information about authors:

Suleimenova Nazia Shukenovna, doctor of agricultural sciences, professor, Kazakh National Agrarian University, Almaty, Kazakhstan; naziya44@gmail.com; https://orcid.org / 0000-0002-3458-3799

Kalykov D., PhD student, Kazakh National Agrarian University, Almaty, Kazakhstan; 2773477@mail.ru; https://orcid.org /0000-0001-8768-086X

Filipova Margaritka, PhD Associate Professor, Angel Kanchev University of Ruse, Bulgaria; mfilipova@uniruse.bg; https://orcid.org/0000-0003-1407-6041

Orynbasarova Gulnar, PhD student; gulnar.86_27@mail.ru; https://orcid.org/0000-0003-4965-9108

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