ISSN 2518-1467 (Online),
ISSN 1991-3494 (Print)

ҚАЗАҚСТАН РЕСПУБЛИКАСЫ
ҰЛТТЫҚ ҒЫЛЫМ АКАДЕМИЯСЫНЫҢ

Х А Б А Р Ш Ы С Ы

ВЕСТНИК

НАЦИОНАЛЬНОЙ АКАДЕМИИ НАУК
РЕСПУБЛИКИ КАЗАХСТАН

THE BULLETIN

THE NATIONAL ACADEMY OF SCIENCES
OF THE REPUBLIC OF KAZAKHSTAN

PUBLISHED SINCE 1944

1

JANUARY – FEBRUARY 2021

ALMATY, NAS RK

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«Қазақстан Республикасы Ұлттық ғылым академиясының Хабаршысы».

ISSN 2518-1467 (Online),
ISSN 1991-3494 (Print)

Меншіктенуші: «Қазақстан Республикасының Ұлттық ғылым академиясы»РҚБ (Алматы қ.).

Қазақстан Республикасының Ақпарат және коммуникациялар министрлігінің Ақпарат комитетінде 12.02.2018 ж. берілген **№ 16895-Ж** мерзімдік басылым тіркеуіне қойылу туралы куәлік.

Тақырыптық бағыты: ***іргелі ғылымдар саласындағы жаңа жетістіктер нәтижелерін жария ету.***

Мерзімділігі: жылына 6 рет.
Тиражы: 2000 дана.

Редакцияның мекенжайы: 050010, Алматы қ., Шевченко көш., 28, 219 бөл., 220,
тел.: 272-13-19, 272-13-18, http://www.bulletin-science.kz/index.php/en/

Типографияның мекенжайы: «NurNaz GRACE», Алматы қ., Рысқұлов көш., 103.

«Вестник Национальной академии наук Республики Казахстан».

ISSN 2518-1467 (Online),
ISSN 1991-3494 (Print)

Собственник: РОО «Национальная академия наук Республики Казахстан» (г. Алматы).

Свидетельство о постановке на учет периодического печатного издания в Комитете информации Министерства информации и коммуникаций и Республики Казахстан **№ 16895-Ж**, выданное 12.02.2018 г.

Тематическая направленность: ***публикация результатов новых достижений в области фундаментальных наук.***

Периодичность: 6 раз в год.
Тираж: 2000 экземпляров.

Адрес редакции: 050010, г. Алматы, ул. Шевченко, 28, ком. 219, 220, тел. 272-13-19, 272-13-18.
http://www.bulletin-science.kz/index.php/en/

Адрес типографии: «NurNazGRACE», г. Алматы, ул. Рыскулова, 103.

Bulletin of the National Academy of Sciences of the Republic of Kazakhstan.

ISSN 2518-1467 (Online),
ISSN 1991-3494 (Print)

Owner: RPA "National Academy of Sciences of the Republic of Kazakhstan" (Almaty).

The certificate of registration of a periodical printed publication in the Committee of information of the Ministry of Information and Communications of the Republic of Kazakhstan No. **16895-Ж**, issued on 12.02.2018.

Thematic focus: ***publication of the results of new achievements in the field of basic sciences.***

Periodicity: 6 times a year.
Circulation: 2000 copies.

Editorial address: 28, Shevchenko str., of. 219, 220, Almaty, 050010, tel. 272-13-19, 272-13-18, http://www.bulletin-science.kz/index.php/en/

Address of printing house: «NurNaz GRACE», 103, Ryskulov str, Almaty.

BULLETIN OF NATIONAL ACADEMY OF SCIENCES
OF THE REPUBLIC OF KAZAKHSTAN
ISSN 1991-3494
Volume 1, Number 389 (2021), 111 – 116 **https://doi.org/10.32014/2021.2518-1467.15**

UDC 631.5:551.5

S. Kenenbayev[1], Djura Karagic[2], G. Yessenbayeva[1]

[1]Kazakh National Agrarian University, Almaty, Kazakhstan;
[2]Institute of Field and Vegetable Crops, Novi Sad, Serbia.
E-mail: serikkenenbayev@mail.ru, djurakaragic@gmail.com, lemesovna@bk.ru

CLIMATE CHANGE AND PRIORITY RESEARCH AREAS IN AGRICULTURE

Abstract. The effect of global climate warming on agriculture, as the most threatened sector of the economy, in the form of reduced crop yields and more frequent manifestations of extreme weather events, is one of the urgent problems that need to be paid close attention. Adaptation of agriculture to climate change is becoming one of the key priorities that need to be developed through the creation of new models of farming systems that would combine the effectiveness of traditional and alternative farming systems while being environmentally friendly and cost-effective. This article considers research issues in agriculture, including the creation of stress-resistant varieties, soil and water and resource-saving technologies, adapted to climate changes, adaptive-landscape, accurate and biological farming systems.

Key words: climate change; adaptation; agro landscape, accurate and biological farming system; technology; potential varieties; productivity.

Introduction Global climate change and its impact on the environment is one of the main problems of the 21st century. It is manifested by an increase in the level of the World Ocean, the melting of glaciers and polar ice sheets (especially in the Arctic), a decrease in the surface area covered by snow and ice, a decrease in the amount of rainfall in the regions, an expansion of arid zones, more frequent tropical cyclones, etc. Changes in precipitation, rising temperatures and other manifestations of global climate change will inevitably lead to more extreme and harsh weather conditions.

Since the beginning of the industrial revolution, atmospheric CO2 reserves have increased by a third, there has not been such a growth rate in the previous 20 thousand years, at least the current level of greenhouse gas concentrations in the atmosphere exceeds the natural level observed over the past 650 thousand years [3]. The main reason for this is the large-scale human use of hydrocarbons as energy sources.

The increase in carbon dioxide emissions (the main component of greenhouse gases) became noticeable with the beginning of the industrial revolution in Europe, marked by the transition to the widespread use of coal, and then, from the late 19th to the early 20th centuries more and more inclusion in the energy balance of the global economy of oil and natural gas. Since the middle of the 19th century the increase in CO2 emissions is strictly correlated with the growth of GDP per capita [4]. Thus, in recent years, the accumulated scientific potential of knowledge has revealed that with a probability of at least 90% climate change is caused by anthropogenic emissions of greenhouse gases.

Agriculture is a major part of the climate problem as one of the participants in global change. It is one of the main sectors of the economy affected by climate change with local, regional and global implications. Currently, it generates 19–29% of total greenhouse gas emissions [5, 6]. Anthropogenic factors have played, are taking place and are playing an equally important role, especially in the degradation of soil and other agricultural lands, as well as the whole biodiversity - vegetation, wildlife, and microorganisms. According to FAO estimates, 50 million hectares of arable land have already been lost due to irrational land use in the world. Currently, 24% or 1.5 billion hectares of the soils in the world are in a state of degradation [7]. And the reason for this process is the unreasonable use of agricultural land and various natural processes. Land degradation and the onset of deserts, up to 5% of agricultural production in the world are lost annually due to droughts, [8]. According to the UN, specialized commission responsible for this problem, the social consequences of land degradation are even more impressive, if we recall that the number of chronically starving reaches 870 million people. The lives of approximately 250 million people are endangered and the living conditions of 1 billion people are getting worse [9, 10].

Climatic conditions of research zones. The impact of climate change on agricultural production conditions is considered on the example of Kazakhstan and Serbia.

The climate features of Kazakhstan that characterize its continental nature include a large amplitude between winter and summer temperatures, air dryness, little rainfall in most of the country, long harsh winters and short summers in the north, short winters and long hot summers in the south. The geographic location of Kazakhstan in latitudinal terms corresponds to the Mediterranean countries with a humid subtropical climate, and the countries of central Europe, characterized by a temperate continental climate. Since Kazakhstan is located in the center of the vast continent of Eurasia, at a considerable distance (thousands of kilometers) from the oceans and seas, their mitigating effect on the climate is insignificant [11].

The climate of Serbia is characterized by continentality in the north with hot in summer (average July temperature 23-25 ° C, maximum 50 ° C) and lingering cold in winter (average January temperature – 1-2 °C, minimum - 25 ° C), moderate continentality in the south and mountain climate in the mountains. Winters in Serbia are short, cold and snowy, summers are warm. The coldest month is January, the warmest is July. The average temperature is 10.9 ° C. Summer does not become so hot with an increase in absolute altitude, winters are more severe with a significant increase in rainfall. The average annual rainfall is 896 mm. Rains most often fall in June and May [12].

Discussions and solutions. The negative effects of climate change are felt in the form of reduced yields and more frequent manifestations of extreme weather events. One of the most important factors in the stability of yield is a sufficient supply of moisture in the soil and the amount of rainfall in the spring, which was defined as a critical period for the moisture demand of wheat. It was found that as a result of higher air temperatures and the sum of effective temperatures, fewer days are expected for flowering and ripening periods after analyzing the results of the number of days required from sowing to flowering and from sowing to ripening.

Yields in northern Serbia are limited by cool temperatures, while yields in southern Serbia are limited by high temperatures and low rainfall [13]. It was established that under the expected climatic conditions of 2030 and 2050 at a $CO2$ concentration of 330 ppm, winter wheat grain yield remains unchanged in most regions except southern Serbia, where the yield will decrease to 12% in 2030 and to 11% in 2050. Forecast of the results of the corn grain yield for 2030 and 2050 at a $CO2$ concentration of 330 ppm shows a significant decrease in yield both in dry conditions and on irrigated lands for all production regions of Serbia. This will be due to higher summer temperatures (June - August) and increased physiological stress in plants due to an increase in the number of summer and tropical days, a significant decrease in precipitation and an increase in the number of dry days during the same period. We can expect a reduction in the growing season due to higher air temperatures and the sum of temperatures analyzing the duration of the growing season for both regimes of growing corn, [14].

The agricultural sector in Kazakhstan is very vulnerable to drought, as it directly depends on the presence of moisture. Although each culture has a different resistance to lack of moisture. Droughts can cause crop failure if weather conditions are unfavorable at the most sensitive growth stage. Most of all from soil and atmospheric drought, the probability of occurrence of which reaches up to 25-68%, crops in the desert zone suffer, where a possible decrease in yield can reach 50-100%. Accordingly, these indicators in the dry steppe zone reach 25-53% and 30-80%, in the steppe 20-47% and 20-60% and in the forest-steppe 15-22% and 10-50% [15].

The main condition for overcoming the current situation many scientists consider the transition to the development and implementation of adaptive landscape farming systems (ALFS) in agricultural production [16.17]. When designing ALFS, the stability of agro landscapes is associated with the biological requirements of plants and must have a specific agro ecological address [18]. Studies have found that on the slopes of the southern and western expositions of the highlands of southeastern Kazakhstan, plane-cutting basic cultivation of light chestnut soils is more adaptive, providing a reduction in their erosion by 3-4 t/ha and an increase in the content of humus and nutrients by 2.0-3.5 c/ha compared to ploughing. A comparative assessment adaptation of winter wheat varieties to the elementary ranges of agro landscapes in the conditions of erosive agro landscapes of the highlands in southeastern Kazakhstan showed that on mountain chernozem (mould humus) and dark chestnut soils. The used variety Bogarnaya

56 provides an average yield of 19.0 kg/ha, while varieties Vitreous 24 and NAZ show yields in the range of 21.1-23.0 kg/ha or 2.1-4.0 kg/ha more, which indicates their higher adaptability [12.13].

These data indicate a high level of ALFS to improve soil ecology, increase crop yields without any means of intensification, that is, due to adaptation, which are a serious reason and the need for more research to develop ALFS in various natural zones of Kazakhstan.

In turn, ALFS is provided with soil-landscape mapping and geographic information system (GIS), agro ecological land assessment using modern informatization tools and remote sensing methods, including a set of various electronic maps [21].

In Serbia large agricultural systems rely on geographic information systems in agriculture in two segments: through the concept of "precision farming" and as part of a decision support system for monitoring and managing the agricultural system. Precision farming allows, in real time, agricultural producers to manage technological processes associated with the cultivation of agricultural land, pre-sowing, sowing and harvesting, as well as to plan future work on the basis of timely information received [22]. The system of precision farming involves designing ALFS and agricultural technologies based on electronic GIS, the allocation of production sites with a uniform soil cover and optimal conditions for moisture, heat supply and soil fertility, precision pre-sowing tillage, precise sowing, differentiated application of fertilizers and other agrochemical products. In accordance with the microstructure of the soil cover and the state of crops, regulation of the production process of special plant varieties according to micro periods of organogenesis using self-tuning automated tools based on electronic control systems.

The spectral reflectivity of green vegetation is a characteristic feature of its elements and must be used for remote diagnostics of the supply of plants with nutrients in the practice of precision farming. The chlorophyll content in plants during the diagnosis of plant mass in the bushing out phase (the responsible phase of planting and crop formation) is necessary for calculating the doses of nitrogen fertilizers during feeding, and the obtained data are used to compile programs for calculating differentiated doses of mineral fertilizers in the precision farming system [23].

Thus, the possibility of maneuvering the sown area structure make it possible to flexibly respond to the level of moisture supply, change the structure of arable land use quickly and use bioclimatic more fully potential in precision farming. It is also possible in accordance with the prevailing weather conditions, as well as, making adjustments to the soil cultivation system; the use of fertilizers; plant protection products and others.

In future water availability will become a serious limiting factor in the development of the economy of Kazakhstan. This is caused by an increasing shortage of water resources associated with their interstate distribution, tight limits on water use, and changes in river flow regimes in the regional water management system, deterioration in the quality of water resources, and salinization of soil.

According to forecasts, the FAO global demand for water resources under the scenario of usual development will increase by 2 times by 2030. A particularly acute situation with water supply is forecasted in the countries of Central Asia [24].

An effective way of rational use of irrigation water is to drip irrigation of crops, where water throughout the entire growing season is supplied in small portions evenly to the roots of plants and irrigation moisture flows only to plants, and is not consumed between aisles. High efficiency of drip irrigation in Kazakhstan was shown when cultivating the most water-consuming field crops, such as rice and sugar beets [25]. A fundamentally new environmental technology has been developed for rice cultivation based on drip irrigation under a mulching film. The improvement of the crop sector should be achieved under the circumstances, first of all, through the use of water, soil, energy and resource saving technologies. The technology of soil-resource-saving agriculture is represented by minimal and zero tillage. Zero tillage is currently practiced from the Arctic Circle to approximately 50 ° south latitude, from sea level to a height of 3000 m, from extremely rainy areas from 2500 mm to extremely dry conditions from 250 mm [26]. Their application allows you to save and even improve soil fertility, significantly reduce production costs, especially in the consumption of fuel and lubricants and significantly increase the efficiency of agriculture as a whole. The issue of increasing potential soil fertility with this technology is solved by creating a biologically active mulching layer through the use of crop residues cultivated in crop rotation.

The experience of world agriculture shows that direct sowing of agricultural crops radically changes the living conditions of plants. Soil temperature is usually lower and humidity higher with zero tillage [27].

Ensuring environmental safety and economic efficiency of modern farming systems is also associated with the biologization of agriculture, which includes the concept of maximum use of biological factors in the farming system and a decrease in the anthropogenic load on the soil. It is due to the composition and alternation of crops in crop rotation on the principles of fertilization, as well as the use of green manure and non-market part of the crop for fertilizer, the use of organic fertilizers and the maximum use of symbiotic nitrogen fixation. It is widely known, for example, the role of plants in increasing soil bio-productivity based on the natural mechanism of its self-healing. Therefore, leguminous plants (white melilot, alfalfa, fluffy vetch, etc.) produce from 2.3 to 10 t/ha of dry matter and fix from 76 to 367 kg/ha of nitrogen [28, 29]. The crop residues of wheat bind mineral nitrogen, thus stimulating the fixation of atmospheric nitrogen by legumes in the next rotation.

Thus, compliance with effective agricultural practices (crop rotation, biologization, etc.) ensures the formation of humic substances in an amount no less than its annual mineralization. So, the biologized crop rotation fields for more than 25 years had a deficit-free humus balance, despite the fact that these crop rotations went through several rotations (eight-field - 3 rotations; five and six-field - 4-5 rotations, and three-field crop rotation - 8 rotations) in southeastern Kazakhstan. [30].

It is known, that ensuring sustainable growth in the size and quality of the crop yield is primarily associated with an increase in the environmental sustainability of cultivated species themselves through selection and agricultural technology; selection of crops and mutual insurers; their adaptive macro-, meso- and micro-zoning increase in species and varietal diversity of agro ecosystems. The emphasis should be placed not only on increasing productivity, but also on the development of stress tolerance of varieties (drought tolerance; frost and winter hardiness; salt and sun resistance).

In Kazakhstan, scientific breeders for 2005-2018 years created 196 varieties and hybrids of agricultural crops, 73 of them are resistant to extreme conditions, namely heat, drought, winter and salt tolerance. 84 of them are resistant to common fungal (stem rust, dusty and hard smut of crops, powdery mildew, blistering smut of corn, rot, fusarium, ascochyta, anthracnose, etc.), bacterial (bacterial spotting, bacterial necrosis or cancer, nectric or tuberculum necrosis), viral (jaundice) plant diseases [31].

Climate warming will also entail the spread of crop pests. The connection has been established between temperature and the expansion of the spectrum of pests over the past 50 years. The variety of phytophages continues to expand (there are 612 pests). New strains are evolving [32]. So, new races of stem rust, such as Ug99, are widespread already in the bordering countries with the Republic of Kazakhstan, the development of which can be intensified on crops of wheat and barley with the expected drought; resistant pathogen - in the past, Phytophthora infestans caused potato hunger in Ireland, etc. In this regard, it is necessary to know the features of climate change for scenarios with a significant increase in average temperatures and precipitation. As well as integrated pest management based on the use of agricultural techniques, crop rotation and optimization of mineral nutrition, widespread use of biological products, scientifically based use of pesticides with differentiation when high-, medium- and poor development of pests taking into account ESTh (Economic severity threshold), the use of modern molecular genetic methods for the diagnosis of phytopathogens, etc.

Findings:

1. Global climate change is caused by more frequent manifestations of extreme weather events, significant fluctuations in the hydrothermal conditions of the growing season, changes in the phases of weed vegetation, susceptibility of pests and diseases to plant protection products and other consequences, which ultimately lead to lower crop yields.

2. It is necessary to intensify research on the possibilities of adapting agriculture and crop production to its change in the context of global climate change:

-use of a science-based farming system, including the optimal structure of sown areas (crop rotation), tillage, wide diversification of crop production and innovative technologies for cultivating crops;

-provision of environmental safety and economic efficiency of modern farming systems, including reducing energy costs and reducing the environmental burden on land resources;

- conducting targeted selection, primarily related to the creation of improved varieties and hybrids of crops that are resistant to environmental stress factors, suitable for various ecosystems and farming methods;

- pilot model creation of a new system of agricultural science organization, integrated into the training process, based on a combination of fundamental and applied science, transfer and adaptation of advanced world achievements.

С.Б. Кененбаев[1], Джура Карагич[2], Г.Л. Есенбаева[1]

[1] Қазақ ұлттық аграрлық университеті, Алматы, Қазақстан;
[2] Егістік және көкөніс дақылдары институты, Нови Сад, Сербия

КЛИМАТТЫҢ ӨЗГЕРУІ ЖӘНЕ ЕГІНШІЛІКТІ ЗЕРТТЕУДІҢ БАСЫМ БАҒЫТТАРЫ

Аннотация. Климаттың ғаламдық жылыну жағдайының экономиканың қауіпті салаларының бірі ретінде ауылшаруашылығына әсері егін шығымының азаюына және төтенше ауа-райы құбылыстарының жиі қайталануы негізінде байқалады және бұл қазіргі уақытта ерекше назар аударуды қажет ететін өзекті мәселелердің бірі болып саналады. Ауылшаруашылығының негізгі басым бағыттары: егіншілікті климаттың өзгеруіне бейімдеу, экологиялық тұрғыдан қауіпсіз, экономикалық тұрғыдан тиімді, егіншіліктің дәстүрлі және балама жүйелерінің тиімділігін қамтитын жүйелердің жаңа модельдерін құру болып саналады.

Бұл мақалада ауыл шаруашылығындағы зерттеулер, соның ішінде стресске төзімді сорттарды құру, климаттың өзгеруіне бейімделген топырақ-су және ресурстарды үнемдеу технологиялары, бейімделгіш-ландшафт, егіншіліктің нақты және биологиялық жүйелері қарастырылады.

Түйін сөздер: климаттың өзгеруі, бейімделу, агроландшафттық, нақты және биологиялық егіншілік жүйесі, технология, сорттардың әлеуеті, өнімділік.

С.Б. Кененбаев[1], Джура Карагич[2], Г.Л. Есенбаева[1]

[1]Казахский национальный аграрный университет, Алматы, Казахстан;
[2]Институт полеводства и овощеводства, Нови Сад, Сербия

ИЗМЕНЕНИЯ КЛИМАТА
И ПРИОРИТЕТНЫЕ НАПРАВЛЕНИЯ ИССЛЕДОВАНИЙ В ЗЕМЛЕДЕЛИИ

Аннотация. Последствие глобального потепления климата на сельское хозяйство как наиболее угрожаемого сектора экономики в виде снижения урожайности сельскохозяйственных культур и более частых проявлений экстремальных погодных явлений – одна из актуальных проблем, на которую необходимо обратить пристальное внимание. Вопросы адаптации сельского хозяйства к изменениям климата становятся одним из ключевых приоритетов, которые необходимо развивать на основе создания новых моделей систем земледелия, которые бы сочетали в себе эффективность традиционных и альтернативных систем ведения сельского хозяйства и при этом были бы экологически безопасными и экономически выгодными.

В данной статье рассматриваются вопросы исследований в сельском хозяйстве, в том числе создания стрессоустойчивых сортов, почвенно-водных и ресурсосберегающих технологий, адаптированных к изменениям климата, адаптивно-ландшафтных, точных и биологических систем земледелия.

Ключевые слова: изменение климата; адаптация; агроландшафтная, точная и биологическая система земледелия; технология; потенциал сортов; урожайность.

Information about authors:

Kenenbayev Serik Barmenbekovich, Head of the Department "Agronomy» Kazakh National Agrarian University, doctor of agricultural Sciences, professor, corresponding member of the national Academy of Sciences RK; serikkenenbayev@mail.ru, https://orcid.org/0000-0003-1745-8475;

Djura Karagic, Head of the Department «Fodder crop», Institute of Field and Vegetable Crops, Novi Sad, Serbia, doctor of agricultural Sciences, scientific adviser, Chairman Forage crop societies Of The Republic Of Serbia; djurakaragic@gmail.com, https://orcid.org/0000-0001-7849-1573;

Yessenbayeva Gulvira Lemisovna, Ass. Professor of the Department of "Agronomy» Kazakh National Agrarian University, candidate of agricultural Sciences; lemesovna@bk.ru, https://orcid.org/0000-0002-4101-3460.

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ISSN 2518–1467 (Online), ISSN 1991–3494 (Print)

http://www.bulletin–science.kz/index.php/en/

Редакторы *М. С. Ахметова, Д. С. Аленов, А. Ахметова*
Верстка на компьютере *А.М. Кульгинбаевой*

Подписано в печать 10.02.2021.
Формат 60х881/8. Бумага офсетная. Печать – ризограф.
20,17 п.л. Тираж 500. Заказ 1.

Национальная академия наук РК
050010, Алматы, ул. Шевченко, 28, т. 272–13–18, 272–13–19