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Review Article

Adaptation of priority research direction in agriculture to climate change in kazakhstan

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Annotation

The negative effects of climate change in agriculture are already felt in the form of reduced yields and more frequent extreme weather events affecting both crops and livestock. It will require a significant investment in adaptation to maintain the current crop and the necessary increase in production, as the most threatened sector of the economy.

Introduction

The review article examined the adaptation of the priority areas of research in agriculture to climate change in Kazakhstan. It includes the optimal organization of the territory based on the identification of landscape-ecological ties, resource-saving technologies, economic efficiency and environmentally friendly modern farming systems, the creation of varieties with specified productivity and quality parameters with full realization of the genetic potential of plants and other consequences.

Currently, climate change is one of the main modern challenges of the 21st century. For example, the unpredictability of weather conditions, which threatens food production, sea level rise, which increases the risk of natural disasters. They are consequences of climate change and are global in nature and unprecedented in scope. If decisive action is not taken today, then subsequent adaptation to climate change will require great efforts and costs [1].

This problem is compounded by the extreme vulnerability of agriculture to climate change. The negative effects of climate change are already felt in the form of reduced yields and more frequent extreme weather events affecting both crops and livestock [2].

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. In addition, anthropogenic factors have played, are taking place and play 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 world's soils are in a state of degradation [3]. Up to 5% of the world's agricultural production is lost annually due to droughts, land degradation and the onset of deserts [4]. 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 [5].

The climate features of Kazakhstan that characterize its continental nature include: a large amplitude between winter and summer temperatures, air dryness, little rainfall in the most part of the republic, long harsh winters and short summers in the north, short winters and long hot summers in the south. The geographical position of Kazakhstan in latitudinal terms corresponds to the Mediterranean countries with a humid subtropical climate and the countries of central Europe that differ in a temperate continental climate. Since Kazakhstan is located in the center of the vast continent of Eurasia, at a considerable distance (thousands of kilometers)

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from the oceans and seas, their soften effect on the climate is insignificant [6].

According to international standards, agriculture in Kazakhstan is carried out in extremely harsh climatic conditions, where the annual rainfall in the main agricultural regions is from 200 to 350 mm. In this regard, it is necessary to intensify research on the impact and opportunities for adapting domestic crop production to global warming in Kazakhstan.

Climatic factors cause significant fluctuations in the hydrothermal conditions of the growing season, which ultimately leads to a shift in the optimal timing of agricultural activities. The main condition for overcoming the current situation is the transition to the development and implementation of adaptive landscape farming systems (ALFS) in agricultural production [7.8]. ALFS must adapt to specific natural landscapes in such a way that it does not violate their environmental sustainability while receiving agricultural products [9]. From many natural factors in the design of ALFS, those that are associated with the biological requirements of plants and, first, determine landscape connections and, accordingly, the stability of agro landscapes, are taken into account. Moreover, ALFS must have a specific agro ecological address [10], so that all their elements or, as previously noted by A.I. Barayev, the entire arsenal of agro technical products was brought into close conformity with specific environmental conditions [11].

The studies have found that on the slopes of southern and western exposures 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 on improving the ecology of soils, increasing crop yields by 1.4-1.7 times with the use of traditional technologies for their cultivation in relation to agro ecological groups and types of land even without any means of intensification, that is, due to adaptation. ALFS is provided with soil-landscape mapping and geographic information system (GIS) of agro ecological land assessment using modern means of informatization and remote sensing methods, including a set of various electronic maps [14], used to create a land valuation basis for precision farming systems [15].

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; identification of the state of crops, yield forecast and product quality based on automated remote monitoring systems, yield mapping during harvesting [16].

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 [17].

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.

Moisture deficiency in the soil was and remains one of the most pressing problems; therefore, it becomes obvious that under the circumstances the improvement of the crop sector should be achieved, primarily using moisture, soil, energy, and resource-saving technologies. Exactly this conservation farming system is a key lever for the survival of farmers engaged in agricultural production today.

The technologies of conservation agriculture also include minimal and zero tillage. Currently, the minimization of soil cultivation has a global development trend, as an important component of high-tech, which is confirmed by world agricultural practice. Areas of application of resource-saving technologies for the cultivation of agricultural crops have a tendency to increase constantly. More than 100 million hectares in the world are crops using resource-saving zero technologies. 26.6 million hectares of land are cultivated in the United States using this technology, 13.5 million hectares in Canada, 25 in Brazil, 19 in Argentina, 12 million hectares in Australia, and 1.2 hectares million in Kazakhstan [18]. The benefits of introducing resource-saving technologies are obvious. 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.

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 [19]. Currently, the most accessible biologization factors for reproduction of

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soil fertility are the composition and rotation of crops in crop rotation based 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. All these factors are aimed at reducing the openness of the cycle of matter and energy in agrocenoses [20]. 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. That is, compliance with effective agricultural practices (crop rotation, biologization, etc.) ensures the formation of humus substances in an amount no less than its annual mineralization [21].

In addition, an important direction of the biologization of intensification processes in crop production is the strengthening of the agro ecosystems adaptive functions in terms of protecting the soil cover from water and wind erosion. Increasing the potential and effective soil fertility (humus balance, physical and granulo metric soil structure, activating soil micro flora and invertebrate saprophages, biological detoxification of pesticides, etc.), preservation of natural structures and mechanisms of self-regulation, control of the dynamics of populations of useful and harmful fauna and flora, etc are also important directions. 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 [22]. The crop residues of wheat bind mineral nitrogen, thus stimulating the fixation of atmospheric nitrogen by legumes in the next rotation. It has been shown that even in those cases when poly cultures (mixed crops) are less productive compared to single-species agrocenoses, they still turn out to be more environmentally sustainable and more efficient from the point of view of using solar energy [23], i.e. provide greater energy efficiency and environmental reliability of the functioning of agro ecosystems.

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).

Increasing the resistance of varieties and hybrids to abiotic and biotic stressors created the opportunity to significantly expand the areas of not only biologically possible, but also economically viable cultivation of such crops as winter wheat, sunflower, corn, soy, peas, clover, etc, as well as, significantly reduce consumption pesticides to ensure ecological balance in agro ecosystems [24].

In Kazakhstan, scientific breeders for 2005-2018 years created 196 varieties and hybrids of agricultural crops, 61 of which are approved for use in production, including, grain is 86, grain forage is 23, corn and sorghum is 29, legumes is 7, oilseeds is 29, fodder is 10, sugar beets is 12. From the created varieties and hybrids of 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 [25].

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 [26]. The rapidly growing shortage of fresh water on Earth, including Central Asia, associated with global warming, puts forward among the priorities the search for ways and means of rational use of irrigation water.

Numerous studies show that drip irrigation of crops is the most effective way to use irrigation water rationally. With such irrigation, water is supplied in small portions evenly to the roots of plants throughout the growing season, and irrigation moisture flows only to plants, and is not spent on aisles. The research has been conducted in Kazakhstan to study the effectiveness of drip irrigation of field crops on irrigated lands in the south and southeast of Kazakhstan: soy, corn, sugar beets and rice. The results showed the high efficiency of drip irrigation in cultivating the most water-consuming field crops, such as rice and sugar beets [27]. A fundamentally new environmental technology for rice cultivation based on drip irrigation under a mulching film is being developed for the first time. The essence of the new innovative technology is that rice is grown without flooding and without the use of herbicides [28].

Based on the foregoing, the main priority areas of research in agriculture in Kazakhstan for global climate change are:

- Development of ecologically balanced sustainable agro landscapes for specific regions, ensuring environmentally friendly farming and reproduction of soil fertility (ALFS).

- Development of a precision farming system, which is the highest form of adaptive landscape farming based on science intensive (GIS) technologies with a high degree of manufacturability.

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- Development of resource-saving technologies that ensure the conservation of soil moisture, reduce energy costs, increase soil fertility and labor productivity.
- Development of a biological farming system that ensures the production of environmentally friendly, cost-effective products and reproduction of soil fertility;
- The creation of improved varieties and hybrids of crops that is suitable for different ecosystems and farming methods and are resistant to climate change.
- Development of water-saving technologies that reduce irrigation water consumption, improve the water-physical properties of the soil and increase crop yields.

Conclusion

Thus, due to its scale and importance, the adaptation of agriculture to climate change should become one of the key priorities that must be developed based on agricultural research institutes. In general, it is necessary to create a model of a new farming system based on a combination of fundamental and applied science methods, transfer and adapt advanced world achievements, and develop such farming systems that would combine the effectiveness of traditional and environmental friendliness of alternative systems and at the same time be economically viable. Moreover, the faster we begin to develop this direction, the sooner the necessary competence will be developed and the greater the chances of a successful solution of emerging technological problems. Otherwise, the pressure of climate change on agriculture will only increase in Kazakhstan.

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