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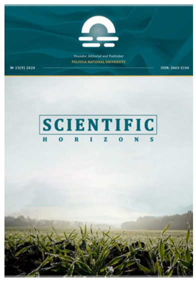

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Influence of the North Kazakhstan Plains Weather on the Productivity of the Spring Soft Wheat

Rustem Zholaman[1*], Elena Fedorenko[1], Timur Savin[2], Kairat Aituganov[2], Vladimir Shvidchenko[1]

[1]North Kazakhstan Agricultural Experimental Station
150311, 19 Tsentralnaya Str., Shagalaly, Republic of Kazakhstan

[2]S. Seifullin Kazakh Agrotechnical University
010011, 62 Zhenis Ave., Astana, Republic of Kazakhstan

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Abstract. Spring soft wheat is a primary agricultural crop of North Kazakhstan, the growing process of which is done in harsh weather conditions due to the fact, that early spring drought and the biggest rainfalls at the end of June and beginning of July, are normal in the region. Due to this fact, scientists and producers have mistakenly believed that in the Northern region, spring wheat should be sown later, adjusting the main phase of plant development "tillering – stem elongation" under the maximum summer rainfalls. The research aims to establish the dependence of spring wheat yield on the amount of spring-summer rainfall at different sowing periods. The following methods were used in the research: field method, methods of clustering, variation, correlation and dispersion analysis. Analysis of observations from 2012-2021 showed that years with an early-spring drought and mid-summer maximum rainfalls were less than one-third of ten and about 60% were years with no spring drought, although the maximum rainfall period was shifted to the June month. However, only one year (10%) was characterized by a severe spring drought and a shift of summer rainfalls to August. The highest yield (26.9 c/ha) of the studied wheat species was observed in years with an atmospheric precipitation shift at the beginning of the summer period and early sowing date. During years of early spring drought with the biggest rainfall in mid-summer, relatively high yields (20.5 cwt/ha) are observed in the later sowing dates. The practical value of the research is determined by the fact, that in Northern Kazakhstan the sowing dates of spring wheat are not closely tied to the calendar dates and depend significantly on the climatic conditions of the region and the weather conditions that prevailed in the spring and summer period of a specific year

Keywords: whether conditions, grain culture, yield, wheat productivity, sowing dates

**Corresponding author*

INTRODUCTION

Soft (by grain hardness) wheat (*Triticum aestivum L.*) is considered the most widely grown grain in the world (90-95%) and the main source of protein, as stated in a systematic review by P. Giraldo *et al.* (2019). The cultivation of crops is closely linked to their resistance to climate change, the improvement of which is a guarantee of global food security, and at the same time poses tremendous challenges to agricultural production around the world. Many scientists stated that drought, caused by decreased rainfalls and higher temperatures, put significant strain on both wheat and other crop yields. A. Batool *et al.* (2019) argue that nearly half of the world's crop area often suffers from either terminal or prolonged drought, which are drought after flowering and drought throughout the development and growth period, resulting in significant declines in grain yields, respectively. Chinese researchers J. Zhou *et al.* (2019) found that water deficiency leads to a shortened grain filling period, decreased number of grains, grain weight, and grain yield.

S. Fahad *et al.* (2021) provided a comprehensive overview of plant-soil interactions in a climate affected by greenhouse gas and organic carbon emissions and management approaches and strategies to stabilize soil organic matter. A. Sehgal *et al.* (2018) found that under drought conditions due to inadequate water supply, there was a decrease in carbohydrate synthesis by wheat plants and an increase in grain protein content. A. do Nascimento Silva *et al.* (2020) proved that nitrogen fertilizer application mitigated the negative effects of drought on wheat production and, to some extent, increased plant resilience. A. Batool *et al.* (2019) cited results from partial and full drought stresses in the root zone of two pot-grown soft wheat (*Triticum aestivum L.*) genotypes in different decades, which showed that both wheat varieties under the induction of non-hydraulic root signal (*nHRS*) improved water used efficiency and yield index, and improved drought tolerance. N. Mi *et al.* (2018) determined the effects of different duration and stages of progressive drought on corn development, yield formation, and dry matter production, which provided the basis for water management strategies.

Noteworthy are the results of pot experiments with magnetized water irrigation under two levels of spring soft wheat drought stress (75% and 50% field capacity, 100% control) conducted by D.A.F.H. Selim *et al.* (2019) in Egypt at the experimental farm of the Faculty of Agriculture, Menufia University, Shibin El Qom. Artificially created drought stress in the greenhouse negatively affected the growth, physiological, biochemical, and anatomical traits of Saha 93 and Sids 9 wheat species. Magnetic water irrigation during two consecutive winter growing seasons (November 20 to May 5, 2014/2015, and 2015/2016) of spring wheat species Saha 93 and Sids 9 overcame completely or mitigated the adverse effects of drought stress on all studied traits. In addition, the application of magnetic water increased grain yield in both varieties by 100-150% compared to the stressed control. It should also be noted the results of a meta-analysis of data from 48 articles (published up to 2020) conducted by Chinese scientists C. Wan *et al.* (2022), showed that drought significantly reduced wheat yield and grain protein yield by 57.32 and 46.04%. Statistical analysis showed that the responses of grain yield and grain nitrogen content to drought were mainly related to drought type and grain protein yield to precipitation. It was also noted that sandy soils and high doses of nitrogen application most significantly mitigated the negative effects of drought, especially for spring wheat.

The study aims to establish the spring soft wheat levels of variability yield depending on atmospheric precipitation at different sowing periods.

MATERIALS AND METHODS

Experimental studies were conducted for ten calendar years (from 2012 to 2021) at North Kazakhstan Agricultural Experimental Station (North Kazakhstan AXS). Agro-technique in the experiment was generally accepted, namely: forecrop – bare fallow, seeding rate – 3.0 million pcs/ha. Terms of sowing: 1st – 10-15 May; 2nd – 20-25 May; 3rd – 30 May-5 June. As a starting material for research were 10 varieties of spring soft wheat: Astana, Astana 2, Asyl sapa, Shortandinskaya 2012, Shortandinskaya 2014, Semenovna, Shortandinskaya 95 improved, Karabalykskaya 20, Omskaya 35, Omskaya 38 which were placed randomly in four replications. The area of the record plot was 25 m^2. Wheat was sown by AMAZONE DMC 3000 seed drill. Seeding rate – 3.0 mln. pcs. per 1 ha.

The cultivated soils of the farm are mainly carbonate chernozems, which by their mechanical composition belong to the clay variety (56.5% clay, 43.5% sand). The bonitet score is 65. Treatment of crops against weeds was carried out with a tank mixture of herbicides – Ether Extra + Grami Super 100 + Galantny. Analysis of agroclimatic conditions was carried out using data from PesslInstruments weather station (iMETOS) of Austrian production, which provides not only highly accurate local meteorological data, but also a highly accurate weather forecast covering 6 days. As it is known, grain culture vegetation consists of the following phases: germination; sprouting; tillering; stem elongation; earing (panicle earing); blooming; formation and ripening of the grain (Aseeva and Zenkina, 2020).

The initial growth phase of spring wheat was phenologically recorded on the day when it occurred, as in all cereal crops, in about 10% of plants, and the end – for the manifestation of signs in 75-85% of plants. The inter-stage period was defined as the time interval from the full previous phase to the beginning of the next one. The duration of the growing season of the variety was calculated from the date of full sprouts to the date of wax (managemental) maturity. Spring soft wheat was harvested by mowing the accounting plots by the harvester ZhVN-6 to the dump and the subsequent threshing of swaths and considering the yield in terms of standard moisture (14%) and grain purity (100%).

Methods of clustering, variation, correlation, and analysis of variance were used for data processing. The experimental data obtained in the form of analytical-numerical material were subjected to mathematical and statistical processing performed by variance-correlation analysis using Microsoft Excel and Agrostat software applications. The study years differed significantly in terms of weather conditions. In 2012, 2015, 2016, 2017, 2018, and 2019, 105.5 mm of precipitation averaged over the growing season with a multi-year average of 81.3 mm, while in 2013, 2014, 2020, and 2021, drought was present and rainfall in May-June was 38.6, 18.0, 32.1, and 81.3 mm, respectively. Consequently, 2012, 2015, and 2018 were more favorable weather years, and 2013, 2014, and 2021 were less favorable. Such contrasting conditions made it possible to study the influence of weather conditions on the duration of interphase periods and the yield of spring soft wheat.

RESULTS AND DISCUSSION

Table 1 shows the rainfall distribution in North Kazakhstan for 2012-2021. Based on this material analysis, it can be concluded that the May-June drought and the strongly pronounced rainfall maximum in mid-summer are not always typical for the climate of Northern Kazakhstan. If the distribution of precipitation in the last decade of this century was to be analyzed (2012-2021), at the first point of the discussion of this issue it can be noted that 60% of the analyzed years (2012, 2015, 2016, 2017, 2018, 2019) were periods, when rainfall was shifted to the early summer period – the month of June, and only one year (2013) was characterized by a later occurrence of maximum rainfall, which is one percent of the studied years of the research. However, the given year on the character of rainfall cannot be attributed to so-called years with the characteristic occurrence of "July" maximum. In conditions of 2013 maximal rainfall has shifted to August which does not correspond to the classical scheme, which is described in the literature. The analysis of the distribution of rainfall over ten years allows concluding that the climate of Northern Kazakhstan is characterized not only by years with a drought in early spring and "July" maximum rainfall. The climate of this region is characterized by years with relatively sufficient rainfall at the beginning of the summer period – June. In comparison with the average multiyear norm of rainfall, the share of such years within the framework of these studies was a significant advantage (Table 1).

***Table 1**. Rainfall distribution character for 2012-2021 (North Kazakhstan Agricultural Experimental Station, North-Kazakhstan region)*

Years	Number of rainfalls by month, mm					Amount rainfalls in May-June, mm
	May	June	July	August	May-August, total	
2011[2]	38.3	89.4	77.9	55.4	261.0	127.7
2013[3]	25.9	12.7	25.3	59.0	122.9	38.6
2014[2]	10.0	8.0	135.6	27.1	180.0	18.0
2015[1]	54.3	82.0	64.0	33.0	233.3	136.3
2016[1]	9.0	85.0	99.0	35.5	228.5	94.0
2017[1]	52.0	31.7	55.9	9.1	148.4	83.7
2018[1]	47.7	52.6	67.9	147.8	316.0	100.3
2019[1]	35.0	56.8	23.0	43.0	158.1	91.0
2020[2]	28.1	35.9	75.6	21.6	161.2	64.0
2021[2]	10.1	22.0	69.8	29.1	131.0	32.1
Average	33.7	47.6	69.5	46.1	196.9	81.3

***Note:** rainfall shift to [1] – beginning of the summer; [2] – mid-summer period; [3] – end summer period; drought of various intensities in 2013, 2014, 2020, 2021*
***Source:** compiled by the authors*

It should be noted that the long-term average of rainfall distribution in the north of Kazakhstan still reflects the so-called characteristic feature of the climate of this region – the maximum rainfall in the middle of the summer period in late June, or early July. This is because during this period in North Kazakhstan only in some years a significant excess of rainfall is observed, which has a significant impact on the multiyear average. In the studies (Table 1), the climatic conditions of 2014 can undoubtedly be attributed to such years.

In this study on the influence of weather conditions on the productivity of different species of spring soft wheat, the distinctive feature was the fact that the sowing dates were combined into the following groups: the first group – conditionally early sowing date – 10-15 of May; the second group – conditionally optimal sowing date – 20-25 of May; the third group – conditionally late sowing date – 30 of May – 5 of June. During the study of spring soft wheat species sowing dates, commonly used in the production crops of Northern Kazakhstan during the last decade (2012-2022), it was found that high productivity in the studied varieties in some years has been noted in the earlier sowing date. In these years (2012, 2015, 2016, 2017, 2018, 2019), a decrease in the productivity of spring wheat varieties was observed when sowing them later. According to the data of Table 2, such years include those in which the rainfall season was shifted to the early summer period, which can be seen from the data of the abovementioned Table 1.

***Table 2**. Influence of the weather conditions and sowing dates (May-June) on the productivity of the spring soft wheat (North Kazakhstan Agricultural Experimental Station, North Kazakhstan region, 2012-2021)*

Climate conditions characteristic by years	Rainfall		Amount of analyzed species, pcs.	Average yield (cwt/ha), acquired from three different sowing periods		
	Average	Average multiyear norm		1st 10...15 May	2nd 20...25 May	3rd 30 May...5 June
No drought: 2012[1] 2015[1] 2016[1] 2017[1] 2018[1] 2019[1]	105.5	81.3	10	26.9	24.9	21.9
Drought: 2014[2] 2020[2] 2021[2]	38.0	81.3	-//-	14.4	18.5	19.4
Drought: 2013[3]	32.1	81.3	-//-	9.8	14.7	20.5

Note: *rainfall shift to [1] – beginning of the summer; [2] – mid-summer period; [3] – end-summer period*
Source: *compiled by the authors*

As such, in the years of a drought of different intensity (2013, 2014, 2020, 2021), when rainfall relative to calendar dates was shifted to the middle of the summer period, the productivity of the analyzed varieties of spring soft wheat increased from early to later sowing date.

Due to climate changes and the variable periodicity of cyclonic rainfalls, and the increased number of heavy rains, there is an excess of moisture when half a month's worth of rainfall occurs in a short period. As a result, moisture cannot fully enter the soil. It either escapes or intensifies erosion processes in rugged parts of the landscape. Therefore, one of the problems of the agro-ecosystems is insufficient soil absorption of rainfalls, significant evaporation of moisture from soil surface during vegetation of crops, and its large losses per unit yield, which is caused by high transpiration coefficient, the consequence of which is underharvesting of crops. At the same time, high atmospheric temperature and reduced rainfall also lead to a decrease in the hydrothermal coefficient and eventually to drought, which negatively affects the agroecosystem: plant growth is sharply reduced, and the development of diseases and pests increases. As suggested by S.S. Baysholanov *et al.* (2018), to measure the level of drought intensity in Kazakhstan, used for many years, a generally accepted indicator in agriculture – Selyaninov's hydrothermal coefficient (HTC), which is calculated for the spring-summer period (May-August) according to the formula:

$$HTC_{5-8} = \frac{\Sigma R_{5-8}}{0.1\Sigma t_{5-8}} \tag{1}$$

where: $HTC_{5\text{-}8}$ – a value of the hydrothermal coefficient for May-August; $\sum R_{5\text{-}8}$ – overall rainfalls in May-August; $\sum t_{5\text{-}8}$ – the overall temperature on average per day from the beginning of May to the end of August.

In the environment of Kazakhstan, the values of HTC criteria (Table 3) given in S.S. Baysholanov *et al.* (2018) are used to assess the atmospheric drought in the period from May to September.

Table 3. *Drought evaluation criteria per HTC*

HTC_{5-8}	Drought intensity
<0.40	Severe drought
0.40-0.59	Moderate drought
0.60-0.79	Slight drought
⩾0.80	No drought

Source: *based on S.S. Baysholanov et al. (2018)*

It is because of the increase in temperature and decrease in rainfall that climatic zones may shift, for example, a moderately humid moderately warm zone will move to a slightly humid moderately warm zone (Baysholanov *et al*., 2018). Thus, the assessment of agro-ecosystems on soil moisture supply per the growing season of crops allows for predicting the level of their yield, assessing the reduction of ecological load through a rational selection of crop varieties, optimization of soil treatment methods to reduce moisture loss in the technology of their cultivation, increase the efficiency of the application of fertilizer and plant protection system against diseases and pests, aimed at reducing the ecological load on agro-ecosystems. The process of rainfall in the North of Kazakhstan is very unstable both in time and quantity. During the research on the weather condition influence on the productivity of spring soft wheat species, it was found that in this region of Kazakhstan in some years the rainfall can be shifted to the period of early summer. The number of such cases (number of years) in the North of Kazakhstan can be quite high. At the same time, it should be noted that such years have a significant impact on the overall grain balance of the region.

For a more detailed analysis of the North Kazakhstan weather conditions impact on the productivity of spring soft wheat species, cluster analysis, i.e., division of the studied objects was used, which are characterized by common features, into homogeneous groups (clusters) in one or another sense from the researcher's point of view. S.S. Kukoleva (2021) notes the identification of the presence of the connection between individual sources of information within the population under study as an important property of cluster analysis. In this research, the study years differing from each other in the character of atmospheric precipitation (Table 1) have been divided into three clusters. Cluster "A" is represented by a series of years with a characteristic shift of rainfall to the early summer period – the month of June. Cluster "B" is represented by the years with early spring drought and the maximum rainfall in the mid-summer period – July. Cluster "C" included only one year, which was characterized by the occurrence of early spring drought and a shift of the maximum summer rainfall to August (Table 4).

Table 4. *Comparative evaluation of spring soft wheat productivity in dependence on rainfall patterns and sowing dates (North Kazakhstan Agricultural Experimental Station, North Kazakhstan region, 2012-2021)*

Year groups with similar weather conditions	**Amount of analyzed species, pcs.**	**Yield (cwt/ha), acquired from three different sowing periods**			**± Against the first sowing period**	
		1st 1…15 May	**2nd 20…25 May**	**3rd 30 May…5 June**	**2nd 20…25 May**	**3rd 30 May – 5 June**
Cluster "A"	10	26.9	24.9	21.9	- 2.0	- 5.0
Cluster "B"	-//-	14.4	18.5	19.4	+ 4.1	+ 5.0
± against the "A" cluster	-//-	-12.5	- 6.4	-2.5		
Cluster "C"	-//-	9.8	14.7	20.5	+ 4.9	+ 10.7
± against the "A" cluster	-//-	- 17.1	- 10.2	- 1.4		

Source: *compiled by the authors*

According to the experimental data presented in Table 4, the highest productivity of spring soft wheat of the ten varieties studied was observed in years with a shift of rainfall to the early summer period when sowing them at the conditional early date – 10-15 May. At later sowing dates (20-25 May) productivity of spring wheat species compared with the first sowing date decreased by 2.0 c/ha, and at sowing 30 May – 5 June by 5.0 c/ha (cluster "A"). In a series of years characterized by the drought in early spring and rainfall in the middle of the summer period (cluster "B"), the opposite pattern was observed. Under climatic conditions of such years, spring wheat species sown at a conditionally early date – 10-15 May – had the lowest productivity. At sowing in a later period – 20-25 May, the yield capacity of spring wheat varieties compared with the first sowing period increased by + 4.1 c/ha, at sowing 30 May – 5 June by + 5.0 c/ha. The cluster "B" represents the year with the occurrence of acute drought in the spring-summer period and rainfall at the end of the summer period – August. Yields of spring wheat species in climatic conditions this year increased from early sowing to later sowing. At the same time, a yield of the wheat species under study in comparison with the conditionally early sowing date – 10-15 of May at sowing in 20-25 of May was higher by 4.9 c/ha and by + 10.7 c/ha at sowing in 30 of May – 5 of June. It should be noted that in the conducted studies, the highest productivity had varieties of spring wheat in a series of years characterized by a shift of rainfall at the beginning of the summer period.

Most of Kazakhstan's export grain is spring wheat grown in the north of the country, where the sown area under this crop reaches 85%, which amounts to about 10 million acres. The main factors influencing the high variability of yields of this crop in this region and limiting its productivity over the past fifteen to twenty years are moisture deficit (average annual rainfall of 320-350 mm) on the background of a drought of various intensity, as the most common and dangerous agrometeorological phenomenon in Kazakhstan, as well as heavy rainfall, hail, frost (Babkenov *et al.*, 2020; Karatayev *et al.*, 2022). From 2005-2010 in the territory of Kazakhstan, the crops were almost destroyed. The number of cases of extreme climatic conditions and weather phenomena showed that atmospheric and soil drought accounted for about 80%, heavy rainfall and hail accounted for 14%, overwatered soils, frost, severe frost with winds – 2% each. Agroclimatic zoning of the territory of Northern Kazakhstan conducted in 2018 by a group of authoritative experts and scientists on heat and moisture availability showed that the bioclimatic potential of spring wheat yield, i.e., the criterion that characterizes the level of crop yield under natural field moisture and calculated using the computer simulation application "climate-soil-yield", is used in this region by about half (the yield is from 30 to 50 c/ha). Consequently, the level of farming in Kazakhstan is not high enough, especially in comparison with Western European countries, where this figure can reach 85% (Baysholanov *et al.*, 2018).

Obviously, in these years, under the conditions of late sowing, the attitude of farmers towards more effective use of rainfall by wheat plants by using agronomic techniques for crop care is quite justified. Numerous literature sources indicate that the main climate feature of Northern Kazakhstan is the nature of rainfall distribution (Zheksenbayeva, 2016; Rysbekova & Sultanova, 2022). The maximum atmospheric rainfall in the region occurs in the middle of the summer period – late June – early July (Sommer *et al.*, 2013; Schierhorn *et al.*, 2020). In the North of Kazakhstan, the drought occurs in early spring, then sharply interrupted in the middle of summer, and continues in autumn. Such distribution of rainfall forces farmers in Northern Kazakhstan to sow spring wheat later, thus adjusting the critical phase of development of spring wheat plants to the maximum of summer precipitation.

In the XX century, after the development of virgin and fallow lands and the introduction of the soil-protective system of agriculture in North Kazakhstan, there was a strong opinion, which now exists as an indisputable official doctrine. The climate of Northern Kazakhstan is characterized by the May-June drought and the occurrence of sudden rainfall peaks in the middle of the summer (Suleymenov, 2020). M.K. Suleymenov (2020) and S. Eliby *et al.* (2022) believe that under the climate conditions prevailing at that time, the later the sowing date of spring wheat strains, the better they use rainfall in the second half of summer and the higher the yield. However, modern research, conducted for the first time, somewhat refutes these statements, which refer to the second half of the twentieth century and have lost relevance in the current time, especially due to the occurred significant changes in climatic conditions, as confirmed in the articles of A.K. Zheksenbayeva (2016), I.I. Zhumagulov *et al.* (2021).

As an illustrative example, it can be cited the study of the impact of rainfall on the yield of spring wheat in the dry-steppe zone of Northern Kazakhstan, which was carried out in 2016-2019 on the production crops in the scientific and experimental farm S. Seifullin Kazakh Agrotechnical University. Due to the analysis of rainfall in the years of research and their impact on the yield, it was concluded that during the vegetation period of spring wheat, the amount of rainfall was not more than 41% of the required average annual rate. The dependence of grain crop productivity on the timing of rainfall was determined, as well as the accumulation of snow on the fields in winter and the reserves of productive moisture in the meter layer of soil in the spring period. It was found that under the conditions of seasonal irregularity of rainfalls during the year in the most demanding moisture phases of grain crops development "stem elongation – earing", the precipitation that fell out in June had a determining influence on the crop yield. The correlation between spring wheat yield and rainfalls in June was 0.61; barley's (for comparison) yield was only 0.41. It was concluded that both spring wheat and barley yields differed significantly from year to year, but annual rainfall amounts did not differ significantly. Contrary to the opinion that years with rainfall in June-July, i.e., mid-summer, are favorable, as it was considered earlier, the average yield of spring wheat obtained in these studies was low and amounted to 14.7 c/ha. It was shown that with insufficient average annual rainfall, especially during the critical phases of spring wheat development, the yield decreased fourfold and was only 3.3 cwt/ha (Zhumagulov *et al.*, 2021; Kurmanbayeva *et al.*, 2021).

Ensuring optimal moisture for crops is one of the most important prerequisites for high yield. The ability of the soil to provide enough moisture to the crop is one of the primary factors of fertility. Famous hydrologist, pedologist, and professor A.A. Rode (1965) states, that knowledge of soil moisture characteristics is needed for the solution of complex issues in agriculture, as moisture, that emerged to the surface, transforms into the ground and is one of the primary nature factors, that influence the mineralization of the organic moisture of the rainfalls. Thus, the soil joint in this chain is one of the most important in the moisture cycle. Other researchers also value these parameters, such as water penetration, moist capacity, and moist keeping abilities of soil as well as moist accessibility for crops. Soil moisture also influences the amount and activity of microorganisms, controls microorganism oxygen access, predetermines the creation of water microorganism stress periods, and may destabilize organic element contents, which leads to the improvement of surface carbon. V.A. Golubtsov *et al*. (2021) determined that the content and composition of soil carbon are not much affected by the ratio of heat and moisture in the growing season compared with the amount of precipitation.

The vast experience in the cultivation of spring soft wheat in Northern Kazakhstan is currently accumulated, although in some years there are quite severe conditions, which are related to the characteristics of the climate and unfavorable unregulated environmental factors. A very short growing season, the systematic nature of cold weather in spring and early summer, large ranges of temperature fluctuations, uneven distribution of precipitation during the growing season, and the onset of early frosts in autumn significantly limit the productivity of spring wheat varieties cultivated in the North of Kazakhstan. It is important to note that rainfall in the middle of the summer period in the North of Kazakhstan is usually followed by relatively high and stable temperatures. This characteristic feature of the local climate is very beneficial for the development of spring wheat, as in the arable soil layer during this period microbiological processes are actively developing, contributing to good plant growth and development of their root system.

CONCLUSIONS

The research results determined that in Northern Kazakhstan, the sowing dates of spring wheat were not closely tied to the specific calendar dates and depend significantly on the climatic conditions of the region and the weather conditions that prevailed in a specific year in the spring and summer period. It was proven that the years with occurrences of severe drought at the beginning of the spring period and rainfall in the middle of summer did not fully characterize the climate of the North of Kazakhstan. Analysis of weather conditions of the past decade (2012-2021) shows that years with occurrences of spring-summer drought and rainfall in the middle of the summer period in this region are not represented by the vast majority. In this regard, the climate of Northern Kazakhstan cannot be characterized as a climate with stable occurrences of drought in early spring and maximum rainfall in the middle of summer. Along with this, given the previously obtained confirming experimental data, it should be recognized that it is in these years acceptable later sowing dates of spring soft wheat, and therefore the orientation of farmers to the predominant use of rainfall by wheat crops, including through agronomic techniques, is quite justified.

In some years, when rainfall shifts to the early summer period, it is advisable to sow spring wheat in earlier terms. In this case, the distinctive feature of rainfall in early and mid-summer accompanied by relatively high and stable temperature is used, which is very advantageous for the development of spring wheat, as the arable soil layer at this time intensively develop microbiological processes that promote favorable development of the root system and plant growth. This provision on sowing dates presents a rather complex scientific and production problem in the cultivation of spring wheat species in the conditions of Northern Kazakhstan. Finding a solution for the issue would help farmers in Northern Kazakhstan to make the right decision when choosing the sowing dates of spring wheat. On this basis, it is worth continuing research on this topic.

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Вплив погодних умов Північно-Казахстанської рівнини на продуктивність ярої м'якої пшениці

Рустем Кабідулайович Жоламан[1], Олена Миколаївна Федоренко[1], Тимур Володимирович Савін[2], Кайрат Капарович Айтуганов[2], Володимир Корнійович Швидченко[1]

[1]Північно-Казахстанська сільськогосподарська дослідна станція
150311, вул. Центральна, 19, м. Шагалали, Республіка Казахстан

[2]Казахський агротехнічний університет ім. С. Сейфулліна
010011, просп. Женіса, 62, м. Астана, Республіка Казахстан

Анотація. Яра м'яка пшениця є основною сільськогосподарською культурою Північного Казахстану, процес вирощування якої проходить в суворих погодних умовах, обумовлених тим, що для регіону характерна ранньовесняна посуха і найбільші опади в кінці червня і на початку липня. У зв'язку з цим науковці та виробники помилково вважали, що в Північному регіоні яру пшеницю слід висівати в більш пізні строки, підганяючи основну фазу розвитку рослин «кущіння – витягування стебла» під максимальні літні опади. Мета досліджень – встановити залежність урожайності пшениці ярої від кількості весняно-літніх опадів за різних строків сівби. У дослідженнях використовували такі методи: польовий метод, методи кластеризації, варіаційного, кореляційного та дисперсійного аналізу. Аналіз спостережень за 2012–2021 рр. показав, що роки з ранньовесняною посухою та середньорічним максимумом опадів становили менше третини з десяти і близько 60 % – роки без весняної посухи, хоча період максимальної кількості опадів змістився на червень місяць. При цьому лише один рік (10 %) характеризувався сильною весняною посухою та зміщенням літнього максимуму опадів на серпень. Найвища врожайність (26,9 ц/га) досліджуваних сортів пшениці спостерігалася в роки зі зміщенням атмосферних опадів на початок літнього періоду та ранніми строками сівби. У роки ранньовесняної посухи з найбільшою кількістю опадів у середині літа відносно висока врожайність (20,5 ц/га) спостерігається за більш пізніх строків сівби. Практична цінність досліджень визначається тим, що в умовах Північного Казахстану строки сівби ярої пшениці не мають тісної прив'язки до календарних дат і суттєво залежать від кліматичних умов регіону та погодних умов, що склалися у весняно-літній період конкретного року

Ключові слова: погодні умови, зернова культура, урожайність, продуктивність пшениці, строки сівби