Conference Paper

Impact of Heat Resources on Rice Productivity in the Sarpinsky Lowland

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Abstract

The possibility of rice cultivation in the northern areas of rice sowing is determined by the sum of effective air temperatures ($\sum t \geq 15$ °C) over the growing season and its distribution over the vegetation phases of the plants. A long-term statistical and correlation analysis of rice productivity depending on the thermal resources of the Sarpinsky lowland at the Maliye Derbeta meteorological station for the period from 1964 to 2018 (correlation coefficient r = 0.68) is given. It is established that the sum of effective air temperatures varies from 3140.2 to 3999.7 °C, while the average annual value is 2820 °C. The highest yield (more than 5 t/ha) of rice grains is formed in years with the sum of effective temperatures over 3000 °C. The fluctuations of air temperature and their influence on the production process, and the yield of rice grains are analyzed, the results of which can be used as source data in modeling climate change scenarios and predicting rice grain production. The optimal amounts of effective air temperatures for the period April-September, ensuring the realization of the potential productivity of rice in the Sarpinsky lowland conditions, are determined.

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1. Introduction

Modern Russian rice growing is a unique and dynamically developing area of the country's agro-industrial complex. The trend of growth of rice yield is possible when using innovative technologies in agricultural production. One of the priorities of the rice industry is the use of climate information for basic research and solving applied problems. With the growth of farming culture, the connection of crops with weather conditions increases, the absolute fluctuations in yield increase, and their amplitude increases [1--4].

The zone of rice-growing in the territory of the Republic of Kalmykia is located within the Sarpinsky lowland and adjoins the northern border of the global area of distribution of rice. However, the territory of the Sarpinskaya lowland has the richest thermal and radiation resources of photosynthetic active radiation (PAR). Thus, the duration of the frost-free period with a temperature above 5 °C is 214 days, and above 10 °C it is 173 days.

The total intake of phased arrays during the growing season of crops (April-October) here is 47.2 kcal per cm^2, which is quite enough for the formation of high yields of almost all crops, even the most heat-loving, including rice [4--8].

The presence of a layer of water in rice paddies during almost the entire growing season eliminates the moisture limit. In this regard, the main factor limiting the formation of the production process and the yield of rice grains in the northern areas of rice-growing are thermal resources. The weather conditions of the Sarpinskaya lowland are characterized by high volatility, which often causes significant fluctuations in yields.

The intensity of photosynthesis of rice plants is associated with the thermal regime of the environment. Thus, the activity of photosynthesis of rice plants is enhanced when the temperature of the flooding layer is 27--32 °C, while the greatest oxygen enrichment of water is noted. In adult plants, the intensity of photosynthesis can be maintained at the same level as the temperature drops to 8 °C [1, 4, 9--11].

In different phases of growth and development, plants experience different needs for heat supply [3, 4]. The minimum temperatures at which the germination processes of the most cold-resistant rice varieties occur are 11.5--12 °C [1, 4, 9--11]. In the phenological phase of development ``tillering'', the most favorable is the temperature of 20--23 °C. The decrease in temperature causes an increase in the number of lateral shoots of rice plants, which leads to its undesirable cultivation.

The water layer is 10--12 cm. At that, the average daily water temperature is 1.5--4.5 °C higher than the air temperature, the more the heat supply of the growing season increases, on average, by 200--250 °C [1--3, 9--11].

During the growing season, the plants undergo the following stages of growth and development: seed germination, seedlings, the third leaf, tillering, entering the tube, panicle sweeping, flowering and ripening. For each phase, the physiological needs for security, heat, and batteries are also different [2, 9--10]. In addition to the main phenological phases of the growing season, 11 stages of organogenesis are distinguished, the duration of which depends on environmental conditions and agrotechnical methods. When water temperature is below 20 °C, the process of balancing is delayed in the differentiation phase. When the weather is favorable, rice blooms and fertilizes within one day, but with a decrease in the average daily temperature, the air color may be delayed for several days. Weather. Thus, lowering the temperature of air and water for 10--20 days leads to metabolic disorders in plants. In such conditions, the beginning of flowering occurs in the II-III decade of August, the fertilization of plants slows down.

The purpose of the study is to assess the heat availability of the Sarpinsky lowland, to establish patterns of influence of air temperature fluctuations on the formation of the production process and the yield of rice grain.

2. Objects and Research Methods

The experimental plot is in the Sarpinska environmental zone in the semi-desert zone of the Republic of Kalmykia. The main source of water for irrigation is r. Volga. Sowing of rice is carried out in the 3rd decade of April -- I-II decade of May, the norm is from 5.5 to 9.5 million viable seeds per hectare [4, 7, 8]. Field experiments were established in accordance with the requirements of the ``Field Experimental Technique under Irrigation Conditions'', mathematical processing of data was carried out by methods of analysis of variance using the program STATISTIKA 10.0.

Meteorological indicators are taken for the period from May to September according to the weather station p. Small Derbety of the Republic of Kalmykia. The interrelationships of rice productivity, temperature conditions during the growing season were revealed for the period from 1964 to 2018. The sum of effective air temperatures for rice plants was calculated as the sum of average daily air temperatures above 15 °C.

3. The Discussion of the Results

Rice cultivation in the northern areas of rice sowing is determined primarily by the total amount of heat during the growing season, or rather, their distribution during this period. Figure 1 shows the main statistical characteristics of the temperature regime for the weather station of Small Derbety (average air temperature during the growing season, monthly and seasonal fluctuations, the sum of effective air temperatures above 15 °C), which can fairly accurately describe the climatic features of the rice growing season for conditions Sarpinsky lowland.

The results of statistical processing of meteorological data over a long-term period (1964--2018) showed a large variability of indicators. The figure clearly shows the synchronism of the oscillations calculated by the ``moving averages'' dates of the spring transition of air temperature through 15 °C, the duration and heat supply of the period with temperatures above 15 °C compared to the rice yield in the Republic of Kalmykia. At the same time, temperature fluctuations oscillate along the trend line, where maxima and minima are noted. The sum of effective air temperatures varied from 3140.2 to

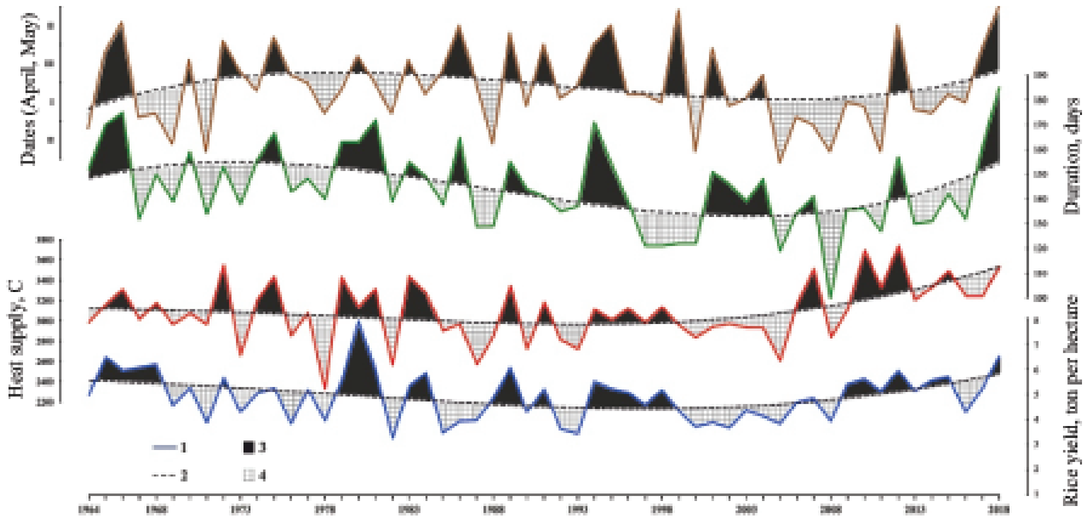

Figure 1: Dynamics of grain yield of rice in the Sarpinsky lowland depending on heat supply (∑t ≥ 15 ˚C), for the period from 1964 to 2018: 1 -- ``moving averages'': 2 -- the trend component of heat supply and rice yield: 3, 4 -- respectively, the values are above and below the trend.

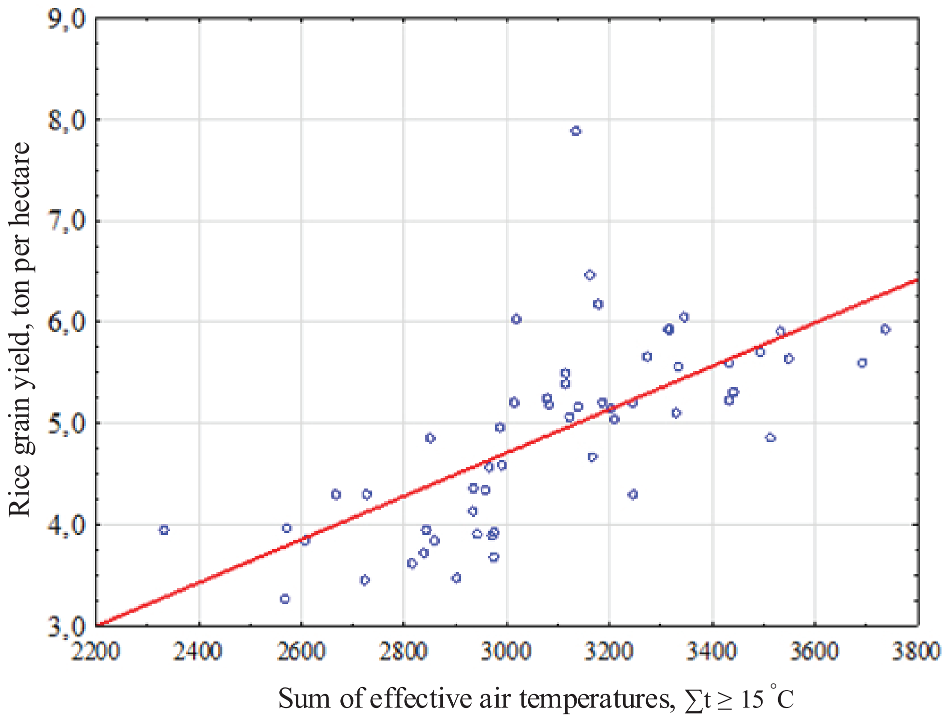

Figure 2: The dependence of grain yield of rice from oт ∑t ≥ 15 ˚C in the Sarpinsky lowland.

3999.7 ˚C, while the mean annual value is 2820.6 ˚C. Minimum indicators of heat supply were formed in 1978, the highest ones were formed in 2010.

The absolute minimum average daily air temperature was observed in July 1986 (17.4 ˚C), the maximum one was in June 1992 (32.6 ˚C). Significant deviations (2.17 ˚C) of the average monthly temperature from the mean annual value were observed in June.

The dependences of the yield on the temperature regime of the growing season, which are characterized by high convergence (r = 0.68), are revealed.

Regression analysis made it possible to establish that with an increase in the sum of effective temperatures in the period from April to September, the yield of rice grains increased by 0.42 ton per hectare. The highest yield (more than 5 ton per hectare) of rice grains is formed in years with the sum of effective temperatures over 3000 °C (Fig. 2).

During the studies, the optimal amounts of effective air temperatures (3000--3400 °C) for rice cultivation in the Sarpinsky lowland during the growing season were determined.

4. Conclusion

The analysis of instrumental observations at the meteorological station of the settlement of Small Derbety for the period from 1964 to 2018 showed a large fluctuation of the temperature regime in the cultivation of rice in the conditions of the Sarpinskaya lowland.

The results of these studies can be used as input data for modeling the scenario of climate change indicators and predicting the production of rice grain.

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