DROUGHT IN THE REPUBLIC OF MOLDOVA BECOMES MORE COMMON AND INTENSIVE

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Abstract

Droughts can be considered the most complex climatic phenomena, because they trigger several factors, namely: atmospheric precipitation, soil water reserve accessible to the plant, humidity and air temperature, evapotranspiration, wind speed, etc., these being the main climatic parameters that define the state of dry or dry weather. This article provides a brief analysis of the statistical data with the most frequent droughts on the territory of the Republic of Moldova. From this point of view, drought risk management is a set of rigorously established and organized activities, which, starting from the existing conditions and objectives of the entity, analyze risk factors in a security concept, in order to minimize risks and costs. Only the precise knowledge of the circumstances, causes of occurrence and legitimacy of manifestation of these phenomena, called in the literature natural hazards or risk phenomena, allows the adoption of appropriate measures to mitigate the negative effects and reconstruction of affected regions. Of particular importance to society is the earliest and most accurate prediction of natural disasters. Drought is a prolongation of insufficient rainfall and is a natural feature of the climate. It can occur in any climatic zone, but its characteristics can vary from one region to another. The evaluations show that the deficit of atmospheric precipitations is practically specific for the whole territory of the republic. The deficit of precipitations and their very uneven distribution condition frequent and intensive droughts. The probability of very strong droughts (≤ 50% of the climatic norm of precipitation) with catastrophic consequences in some months of the vegetation period on the territory of the Republic of Moldova is 11 - 41%.

Key words: affected regions, climate parameters, drought, mitigation measures, risk

Droughts can be considered the most complex climatic phenomena, because they trigger several factors, namely: atmospheric precipitation, soil water reserve accessible to the plant, humidity and air temperature, evapotranspiration, wind speed, etc., these being the main climatic parameters that define the state of dry or dry weather (Constantinov T. *et al*, 2008).

To these are added other factors that define the characteristics of the active surface (relief features, soil, water table depth, degree of vegetation cover, etc.), factors that define the physiological characteristics of the plant (such as variety and vegetation phase, degree of drought resistance), as well as factors that highlight the anthropogenic influence on the environment (the condition of the land and the agrotechnics used that can facilitate the depletion of water in the soil).

As a complex meteorological phenomenon, drought is generally characterized by the absence of precipitation, as well as by the increase of potential evapotranspiration (Corobov R. *et al*, 2007).

As the absence of precipitation can occur in all months of the year, the phenomena of drought and drought can occur in all seasons with obvious consequences on agriculture (Corobov R. 2008; Kuharuk E. *et al*, 2015).

One can thus speak of winter, spring, summer, autumn droughts with differentiated consequences, in relation to the crop development phase.

Although droughts can occur throughout the year, most occur in late summer and early fall.

According to the intensity, there are several types of droughts (very strong, strong, moderate, weak).

Very strong droughts are reported in the years when during the vegetation period precipitation falls less than 50% of the norm, and the average air temperature exceeds the climatic average by 3 - 4 °C. Strong droughts occur when the amount of precipitation is 60 - 70% of the norm, and the average air temperature during this period exceeds the norm by 2 °C. Moderate droughts are reported in those years when 70 - 80% of the precipitation rate falls, and the positive

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temperature anomaly is 1.0 - 1.5 °C (Sofroni V. *et al*, 1998).

When increasing the degree of drought intensity, each component of the complex of natural or anthropic factors participates with a differentiated weight, in relation to the season, the vegetation phase, the agrotechnical works, etc.

Drought in Moldova is one of the most dangerous phenomena of nature, representing the specific feature of the regional climate, conditioned by the uneven distribution in time and space of atmospheric precipitation against the background of high air temperature values.

The evaluations show that the deficit of atmospheric precipitation is practically specific for the entire territory of the republic (Kuharuk E. *et al*, 2015).

The probability of very strong droughts (≤ 50% of the climatic norm of precipitation) with catastrophic consequences in some months of the vegetation period on the territory of the republic is 11 - 41% (Sofroni V. *et al*, 2000).

Droughts have been reported more frequently in the last two decades, and they are becoming more intense. Therefore, during the years 1990 - 2019 on the territory of the republic were registered 29 years (1990, 1992, 1994, 1996, 1999, 2000, 2001, 2003, 2007, 2011, 2015, 2017, 2019) with droughts of different intensity, which led to a decline in crop yields (Sofroni V. *et al*, 1998, 2000; www.old.meteo.md).

In the years 1990, 1992, 2003, the droughts lasted throughout the vegetation period (months IV - IX), in the rest of the years the droughts were reported in summer (www.old.meteo.md).

MATERIAL AND METHOD

In Moldova, the effects of agricultural droughts are exacerbated by low rainfall due to relatively high land slopes, which favor runoff that occurs during heavy rains.

In this paper, the relative losses of agricultural production were analyzed, depending on the intensity of droughts and their variation at the multiannual average level on the territory of Moldova. The production deficit every year was established by simulating the dynamics of the water balance, with the help of calculation programs over a series of 29 years (1990-2019), with the real course of precipitation and consumption specific to each crop.

The State Hydrometeorological Service of Moldova, based on the detailed analysis after years of the hydrothermal coefficient (CHT), established that the value CHT ≥ 1.0 characterizes a sufficient humidity, CHT ≤ 0.7 denotes a dry climate, CHT = 0.6 a mild drought, CHT ≥ 0.5 a strong and very strong drought.

Air temperature is the element that gives the most clues about what the weather will be like in a certain period of time. Temperature measurements are mainly affected by the environment, namely: the presence of buildings and other obstacles, the condition of the soil surface, vegetation, etc. The instruments for measuring the air temperature are located at a height of 2 m from the ground surface inside the meteorological shelters.

The meteorological shelter is designed to allow free air circulation around the thermometer, being located on a ground covered with vegetation, at a certain distance from buildings or other heat sources. It is important to note that air temperature is not measured in the sun.

The temperature and humidity of the air (3 stations), the intensity of precipitations (15 stations), the duration of the Sun's brightness (8 stations), the barometric trend (18 stations) are recorded with a series of stations.

RESULTS AND DISCUSSIONS

The intensification and expansion of extreme climate phenomena, decreases every year the agricultural production by at least 30-50%. According to the database of the State Hydrometeorological Service (SHS), it appears that from the amount of precipitation and temperature variation, the soils are affected, for long periods and in consecutive years, more or less by frequent droughts (www.old.meteo.md). Thus, heat, as an element of stress on agricultural plants, is a climatic hazard with a long period of installation and is characterized by lower rainfall below average, by reducing river flows and groundwater reserves, which causes a large deficit of moisture. in air and soil, with direct effects on the environment and primarily on crops. Drought leads to large losses of agricultural production. Its consequences in the past were particularly severe, especially when they were dry for two or three years in a row (*figure 1*).

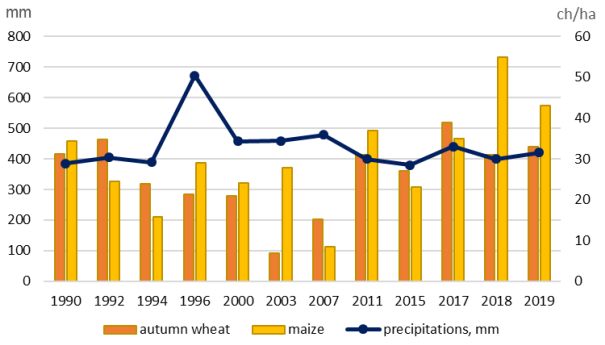

Figure 1 **Rainfall in the driest years and yield per hectare of the main cereal crops in Moldova**

The beginning of the drought is considered to be when the difference in monthly precipitation-

evapotranspiration values becomes negative, which determines the reduction of the water supply in the soil and can affect the quantity and quality of the harvest (Petcu E., 2008).

During the growing season, different crops and plant associations have different requirements for water needs, so that a period of drought does not simultaneously affect the entire cultivated or natural vegetation.

According to the intensity, there are several types of droughts (very strong, strong, moderate, weak).

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Moderate droughts are reported in those years when 70 - 80% of the precipitation rate falls and the positive temperature anomaly is 1.0 - 1.5°C.

When increasing the degree of drought intensity, each component of the complex of natural or anthropic factors participates with a differentiated weight, in relation to the season, the vegetation phase, the agrotechnical works, etc.

The territory of the Republic of Moldova belongs to the area with insufficient humidity. The amount of precipitation decreases from northwest to southeast from 620 to 490 mm during the year.

Precipitation falls mainly during the warm year of the year in the form of short-term rain showers and only about 10% of their annual amount - in the form of snow.

The wind regime, which is formed under the influence of baric centers, is characterized by the highest repetition in the northwest (12–35% per year) and southeast (15–25%). The average wind speeds during the year oscillate on the territory from 2.5 to 4.5 m/s.

The consequences of drought are determined by the degree of intensity, duration, and the affected area. Lack of water in the soil and extremely high temperatures are the main cause of drought. According to preliminary data, the drought of this year 2020 also caused great damage to agriculture.

Droughts covering an area of up to 10% of the territory of the Republic of Moldova were assessed as local; 11-20% are considered - vast; 21-30% - very large; 31-50% - extreme, and above 50% are considered catastrophic droughts, because they cause great losses to the national economy.

The productive moisture reserves in the arable layer of the soil on the lands with autumn crops (60% of the territory) constituted 25-35 mm (75-135% of the norm), on 40% of the territory - 5-20 mm (15-65% of the norm).

On 70% of the territory in the soil layer with a thickness of 1 m the productive moisture reserves constituted 105-205 mm (85-145% of the norm), isolated (30% of the territory) - 55-90 mm (45-75% as a rule).

The productive moisture reserves in the arable layer of the soil on the plowed lands (60% of the territory) constituted 10-20 mm (45-75% of the norm), on 40% of the territory, mainly in the northern districts of the country - 25- 40 mm (90-150% of the norm), in the soil layer with a thickness of 1 m on 50% of the territory - 110-180 mm (100-140% of the norm), in the rest of the territory - 75-95 mm (60- 75% of the norm).

The productive moisture reserves in the soil layer with a thickness of 1 m in the perennial plantations on 60% of the territory constituted 60-95 mm (45-75% of the norm), on 40% of the territory - 110-155 mm (80-135% of the norm).

The reserves of productive moisture in the soil on the plantations with agricultural crops are reduced, isolated in the arable layer and in the one with a thickness of 0.5 m they are totally exhausted.

The productive moisture reserves in the soil layer with a thickness of 0.5 m on the lands with corn sowing (70% of the territory) in the background constituted 5-40 mm (10-65% of the norm), in the rest of the territory - 50- 60 mm (75-90% of the norm). In the soil layer with a thickness of 1 m on 80% of the territory the productive moisture reserves constituted 25-75 mm (25-60% of the norm), in the extreme northern and isolated districts in the southern ones - 90-130 mm (75-90% of the norm).

The catastrophic drought of 1994 on the territory of the Republic of Moldova manifested itself during the entire warm period. In the spring season 87% of the territory of the republic was affected by drought with a strong and very strong degree of intensity. In summer, the dynamics of the hydrothermal conditions contributed to the decrease of the surface occupied by the given phenomenon up to 40% of the territory, and in the autumn months the drought covered the entire territory. Approximately 70% of the republic's surface was affected by the very strong drought, the CHT values were below 0.3, which caused great damages to the national economy (over 1 billion lei).

The catastrophic drought of 2007 on the territory of the Republic of Moldova started

practically from the autumn of 2006. Thus, between 01.09.2006 - 06.08.2007, the amount of precipitation falling on the territory of the republic constituted in fact 50 - 70% of the climate norm. The situation worsened to the maximum between May and July 2007, when the amount of precipitation made up only 30% of the norm. The uninterrupted interval without precipitation in the mentioned period varied within the limits of 28-73 days, and the number of days with the relative humidity of the air ≤ 30% constituted in the territory 55-78 days, exceeding 3-4 times the climatic norm. Between May and July 2007, the average air temperature in the territory was 21 - 23 °C, being 3 - 4°C higher than the norm (record). The number of days with maximum temperatures ≥30 °C constituted in the territory 36 - 45 days, exceeding the norm 3 times, and the number of days with maximum temperatures ≥35°C, respectively 10-12 days. Thus, the deviation from the norm was exceeded 10-12 times. On July 21, the maximum record air temperature of 41.5 °C (Camenca Meteorological Station) was recorded. The high thermal regime and the insufficiency of precipitations in May-July created unfavorable conditions for the autumn crops during the formation and filling of the grains (flowering-ripening in milk), the growth, development and formation of the crop for weeds, vegetables and fruit trees. The agro-industrial sector suffered the most. The average harvest of autumn wheat per republic, in 2007, was 15.3 ch/ha, being 2 times lower than the average size of the forecasted crop and lower by 10-11 ch/ha than the average yield for the last 10 years. The harvest of the main late agricultural crops (maize, sunflower, sugar beet, tobacco, fruit trees) was largely compromised, and the enterprises of the mentioned sector were left without raw material. A very serious situation regarding feed insurance has been created in the livestock sector. The catastrophic drought of 2007 affected over 80% of the republic's territory, being the most severe drought for the entire period of instrumental measurements. According to the main agro-meteorological indices, this drought overcame even the drought of 1946, causing damages to the national economy in the amount of over 1 billion American dollars.

The catastrophic drought of 2011. During 2011 the rainfall fell very unevenly. On 60% of the country's territory (basically in the northern districts of the republic and isolated in the central and southern ones) a large deficit of precipitation was reported. Their amount was 290-415 mm (50-75% of the annual norm), which is reported in the northern districts of the country on average once in 20-30 years, and in the rest of the territory - on average once in 5-10 years. On 40% of the country the amount of precipitation fell close to the norm - 430-545 mm (80-105% of the annual norm). The average amount of precipitation on the territory of the republic was 400 mm, which places 2011 on the sixth place in the series of the driest years in the last 60 years (1951, 1953, 1986, 1990, 1994). The drought of 2011, on the territory of the Republic of Moldova, manifested itself in the second half of the warm period. Between August 1 and October 8, 2011, a high thermal regime was reported everywhere (2-2.5 °C higher than the norm) and with a significant deficit of precipitation (10-50% of the norm), which led to the onset of catastrophic drought that affected over 80% of the country's territory. Such a high thermal regime and considerable insufficiency of precipitation, in the mentioned period of 2011, was reported for the second time for the entire period of instrumental meteorological observations. The analog year is 1952.

Between August 1 and October 8, 2011 the hydrothermal coefficient (CHT), which characterizes the degree of humidity of the territory, constituted on the territory of the republic on average 0.1-0.4, which corresponds to the strong and very strong drought. Due to the large deficit of productive moisture in the soil, difficult conditions were created for weight gain and sugar accumulation in sugar beet, which negatively affected the quantity and quality of the fruit. Prolonged dry weather and very deficient soil moisture in the soil have caused critical conditions for sowing and developing autumn crops. Agricultural households began sowing cereal crops only at the beginning of the second decade of October. According to the Ministry of Agriculture and Food Industry, 77% of the land planned for autumn crops (272 thousand ha) were sown in the autumn of this year. The very dry weather continued during November. This month, the precipitation, in fact, was missing or their isolated amount was 1-3 mm, which on 75% of the country's territory is reported for the first time in the entire period of instrumental observations. Thus, the development of autumn crops took place weakly and unevenly, with a delay of 1.5 months compared to the usual deadlines, due to unfavorable agrometeorological conditions and sowing in late terms.

The interruption of the vegetation of autumn crops, which is signaled with the decrease of the average daily air temperature to + 3 °C and below, in 2011, took place on November 10 (10-15 days earlier than usual), which is reported on average once in 5-7 years. At the time of the vegetation interruption (November 10) on 60% of the territory

of the republic the autumn crops were in the phase of emergence, on 25% - in the phase of sprouting of the grains and only on some lands (15% of the territory) - in the phase the appearance of the third leaf, remaining undeveloped and weakly rooted. The agro-meteorological conditions established in August-November 2011 were unfavorable for the growth and development of autumn crops. Such a case, when the autumn crops on 1/4 of the sown lands entered in winter only in the germination phase of the grains, takes place in the Republic of Moldova for the first time in the last 60 years. In the years with partially similar agrometeorological conditions (1952-53, 1963-64) the harvest of autumn crops was only 9-14 (quintals/ha).

Many environmentalists, rightly, do not look favorably on irrigation. If technological requirements are not met, irrigation can lead to accelerated soil degradation through erosion, salinization, wilting, etc. In this case, the role of specialists in the field (hydrotechnicians, pedologists, hydrologists, others) increases considerably, but, unfortunately, we have lost them, for the most part, during the last 20 years. Now we need to get back to their better preparation.

From the point of view of the sustainable use of water resources, the emphasis must be on water from the Dniester and Prut rivers. It is dangerous to pay attention to the water sources of small rivers. Due to overexploitation, a large part of them have dried up and the process is growing.

The small amount of precipitation affected the wells and springs in the villages, in many of them the water disappeared or its quality worsened. There is talk of drying 10% of the wells, but in reality the situation is much worse. Hundreds of thousands of families are forced to bring water from long distances, to limit consumption for household purposes. The plots of land near the house could not be watered and the villagers went to the market for vegetables, thus contributing to higher prices. The only possibility for the rural population to survive in these conditions is the development of water supply and sewerage systems. The construction of aqueducts must become a national priority.

In addition, one should teach people to accumulate and use the minimum amount of water they have rationally; to build rainwater accumulators which are then used in the household, including for irrigation; to clean and deepen the wells, but not when the water runs out, but every year; to work the agricultural land properly, reducing, as much as possible, the process of evaporation of water in the atmosphere; to incorporate organic fertilizers into the soil. These measures can reduce the losses of citizens, being an effective remedy against drought. And agricultural insurance, no doubt, must be much more widespread.

Climatologists say droughts will become more frequent and severe. Our experience in combating this phenomenon is modest. I believe that we should take up the practice of managing water resources from countries in the climate zone with a permanent deficit of rainfall, such as Israel, some Arab countries and Central Asia.

Drought mitigation and control measures. As it is known, several methods are used to mitigate the risks of drought in agriculture: irrigation, cultivation of drought and drought-resistant plant species, application of advanced agrotechnical systems, use of fertilizers.

The most effective measures are irrigation. They influence the hydrological regime of the soil and the lower air layer having a double role: on the one hand, it provides the productive moisture necessary for the plants, and on the other hand, they reduce the thermal effect and diminish the evapotranspiration processes.

Depending on the technological level of the respective company, different types of irrigation can be used: based on sprinklers, based on sloping or non-sloping irrigation canals, or by drip which reduces the loss of water and energy used for supply.

Irrigation must be used, based on proper synoptic monitoring. Otherwise, the application of irrigation is not only unprofitable, but can trigger other risks and aggravate the evolution of the agricultural landscape in an undesirable way. Monitoring measures are needed to ensure the efficiency of these works to ensure a normal evolution of the agricultural landscape.

In order to increase the resistance of agricultural crops to the conditions of high thermal regime and high deficit of productive moisture in the soil, selection and improvement works of crop plants are carried out, leading to hybrids with deeper root system, which can use the reserve. of water from the deep horizons.

In order to reduce the negative effects of the mentioned phenomena, such measures are used as: ecological location of agricultural crops, planting of protection strips, use of black fields, snow retention, terms and optimal sowing norm, differentiated tillage.

CONCLUSIONS

Drought is generally a problem of meteorology, which depends on the level of precipitation, but its intensity depends to a

considerable extent on the characteristics of the soil in the affected area. Thus, the effects of drought can be intensified by the loss of part of the water from precipitation on soils with low water retention capacity, low permeability or compacted, or located on sloping land.

The intensity, duration and extent of the phenomenon of pedological drought vary from one year to another, depending on the complex interaction of agrometeorological factors, respectively particularly high maximum temperatures in the air (days of heat) and soil, associated with a low relative humidity (atmospheric drought) and a poor rainfall regime.

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