THE INFLUENCE OF CROP ROTATION AND FERTILIZATION ON AGRICULTURAL YIELD IN THE CONTEXT OF CLIMATE CHANGE ON SLOPED LANDS IN THE BÂRLAD PLATEAU

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Abstract

In Romania, severe droughts of varying intensities frequently impact large parts of the country, particularly the southern and eastern regions. Sloped agricultural lands, prone to erosion, cover approximately 43% of the country's agricultural area. Due to their extent and productive potential, these lands play a decisive role in Romanian agriculture, including in drought-affected areas. In addition to achieving competitive yields, soil conservation on these lands is essential. In this context, it is necessary to adapt and integrate both traditional and innovative methods to reduce soil erosion to acceptable limits and improve soil fertility. In the Bârlad Plateau, the topographical conditions and lack of water sources prevent the use of irrigation on sloped lands to offset moisture deficits, leaving crop production dependent solely on precipitation. The aridity of the region is exacerbated not only by the lack of rainfall but also by the terrain, which reduces the effectiveness of precipitation through runoff and diminishes the soil's water retention capacity due to surface erosion. This study investigates the role of crop rotation and fertilization in the quality and quantity of the primary agricultural crops on sloped lands in the upper sub-basin of the Țărnii Valley, Bârlad Plateau, over the past 10 years, in the context of climate change. The research highlights how rainfall patterns and surface runoff impact crop yield and emphasizes the importance of efficient soil and water resource management in areas at high risk of erosion.

Key words: drought, slope, rotation, erosion

The global climate evolution manifested by the increase in the average temperature, the change in the regime and the amounts of precipitation, have determined in the last decades, an increase in the areas affected by drought worldwide. The climatic framework of Romania is generally characterized as "moderate continental", but there is a great variability of it, both geographically and from one year to another. The extremely large variation, both in the total amount of precipitation from one year to another, and in its distribution throughout the year, causes water deficits during the vegetation of agricultural crops, in almost all areas of the country. These are accentuated in recent years due to climate change.

Plants are exposed, throughout their life, to numerous stress factors, which produce changes in the normal physiological functioning of all plants, including with important economic effects in crop plants. Due to the sedentary way of life, plants resort to a series of adaptive strategies regarding the response to different types of abiotic stress (drought, salinity, radiation, high or low temperatures, flooding, etc.) and biotic (pathogens, competition with other organisms), which alter the plant-environment balance (Epstein E. *et al*, 1980), reduce the biokinetic capacity of the plant, and cause damage that can kill the plant. Of all these natural stress factors to which plants can be exposed, drought affects 26% of the arable surface of the earth, thus limiting the most the distribution of plants and their productivity, both in natural and agricultural systems (Hanson A.D., Hitz W.D., 1982).

The rational use of sloping agricultural land implies the fulfillment of two major objectives, namely: soil and water conservation; the use of appropriate culture technologies. These objectives refer to the technical and agrotechnical methods of combating soil erosion on agricultural land. Indirectly, however, they also aim at issues related to preventing and combating the effects of drought because through the works of organization, development and soil erosion control exploitation of the lands, the aim is primarily to reduce liquid leakages on the slopes and, implicitly, to increase the water reserve in the soil.

The dry nature of the area is determined not only by the lack of precipitation but also by the relief that reduces their efficiency through surface

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runoff and the reduction of the useful water capacity of the soil, as an effect of surface erosion. The shock of droughts is felt much more strongly by the population in the hilly area. Due primarily to water losses caused by runoff on slopes, the level of agricultural production is lower compared to flat land.

MATERIAL AND METHOD

The experiments are located on the right slope of Tarna Valley on land with a slope of 12-13% on a moderately eroded cambic chernozem type soil, within the S.C.D.C.E.S. "Mircea Moțoc" Perieni. The experience is stationary and was established in 1969. In the present study, only the data obtained during the period 2013-2023 was analyzed.

Wheat and corn crops that are predominant in the research area were studied. The factors studied for both cultures were A – the type of rotation and B – the dose of fertilizers.

For the wheat crop, the A factor comprises 5 gradations:

- Wheat monoculture;
- Two-year wheat / corn rotation;
- Three-year rotation wheat / maize / peas;
- Five-year rotation with spring soil: wheat-maize-peas-sunflower-alfalfa

For the wheat crop, factor B also includes 5 fertilization options:

- Unfertilized (control);
- $N_{32}P_{32}$;
- $N_{96}P_{96}$;
- $N_{128}P_{128}$;
- Manure 50 t / ha (once every 5 years).

Biological material used. During the research, different varieties of wheat from higher biological categories and from those zoned in the Bârlad Plateau were cultivated.

The experiments were located with the length of the plots in the general direction of the contour lines. The soil works in accordance with the agrotechnics specific to each crop depending on the conditions of the year, so that an attempt was made to ensure a germinative bed as well prepared and uniform as possible.

Nitrogen and phosphorus fertilizers were applied fractionally, 1/3 before sowing and 2/3 of the total dose during the growing season of the crops. Fermented manure was applied once every 5 years under the basic plowing. Weed control was carried out with the recommended herbicides, aiming at the optimal application period. The experiments were laid out according to the method of subdivided plots in five repetitions.

Grain production in kg per plot, weighed to two decimal places, was recorded for each repetition. Grain moisture was determined with a moisture meter immediately after harvest and weighing was also recorded for each repetition.

The samples taken from the field were determined in the laboratory, consisting of: the weight of 1000 grains and the hectoliter weight.

RESULTS AND DISCUSSIONS

Climatic data

The values of the meteorological elements (temperatures, precipitation) indicate the presence of a temperate-continental climate of excessive nuance, with hot, dry summers and cold winters.

The data used were recorded at the weather station at the Perieni Research Station.

The rainfall regime is of particular importance because the production is directly dependent on the amount of precipitation and its distribution over time, and on sloping lands the volume of liquid runoff and erosion largely depends on the torrential nature of the rain.

More than 47% of the annual volume of precipitation falls in the critical season of erosion, which explains the high values that erosion registers in the Bârlad Plateau. Also, about 18% of the annual volume of precipitation occurs when the soil is bare, freshly tilled and easily erodible.

The analysis of the annual rainfall amounts recorded between 1941-2023 (*figure 1*) reveals a cyclical tendency of approximately 40 years, in which the rainy interval alternates with the dry one. The 5-year moving average, which conclusively expresses the climate evolution trend, suggests that in the period 1942-1957 the phenomenon of drought was specific and in the interval 1958-1984 the precipitation exceeded the multiannual average of 493.1 mm. Since 1985, the drought phenomenon has re-established itself, tending to continue even today.

The average annual temperature varies between 8.0°C and 13.0°C, the coldest month being January (-2.7 0C) and the warmest July (21.8°C). The transition between these limits is done gradually.

The analysis of monthly values from the interval 1941-2023 (*figure 2*) highlights a multi-year average of 10.1°C, a minimum of -11.5°C in January 1942 and a maximum of 26.2°C in July 2012. Temperature records the absolute maximum was 39.7°C and was recorded on July 25, 1942.

Influence of crop rotation and fertilizers on wheat production

In the long-term experiments with rotations and fertilizers, the influence of rotation and fertilizers on production was followed by the method of analysis of variance independently for each type of rotation. Statistical analysis of production data on each type of rotation revealed the effect of chemical and organic fertilization on wheat production.

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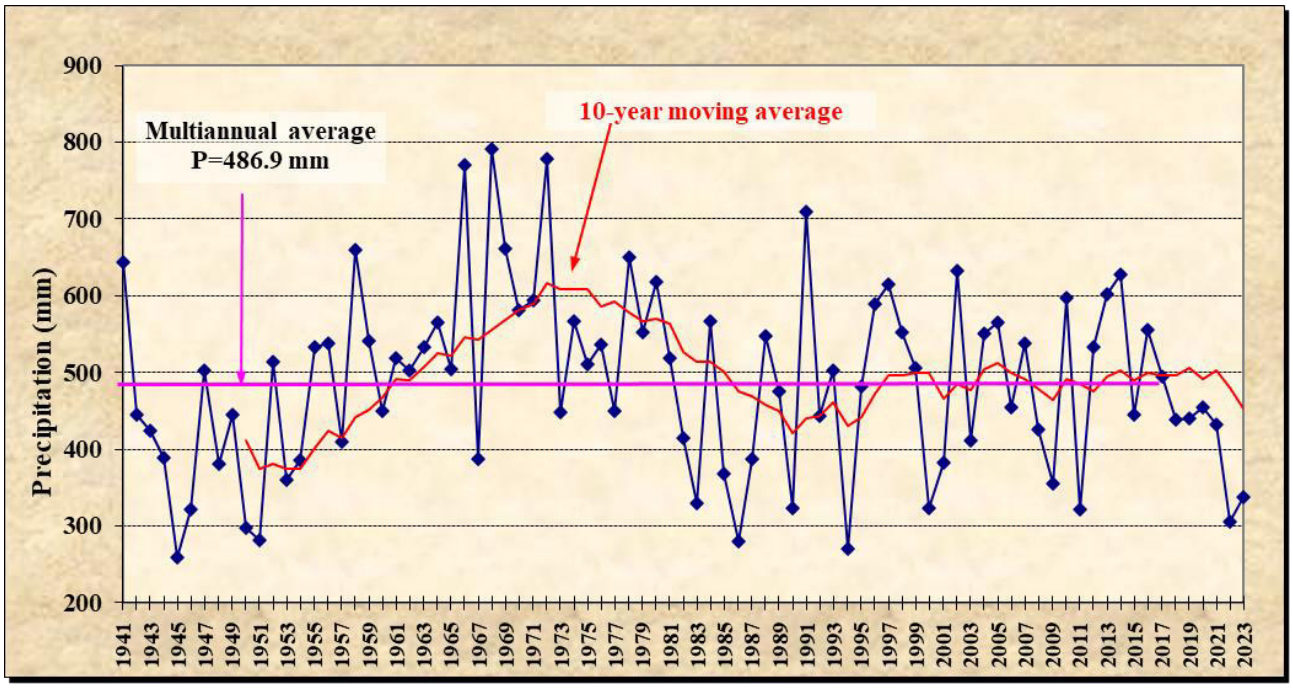

Figure 1 **Distribution of multiannual average precipitation in the period 1941-2023**

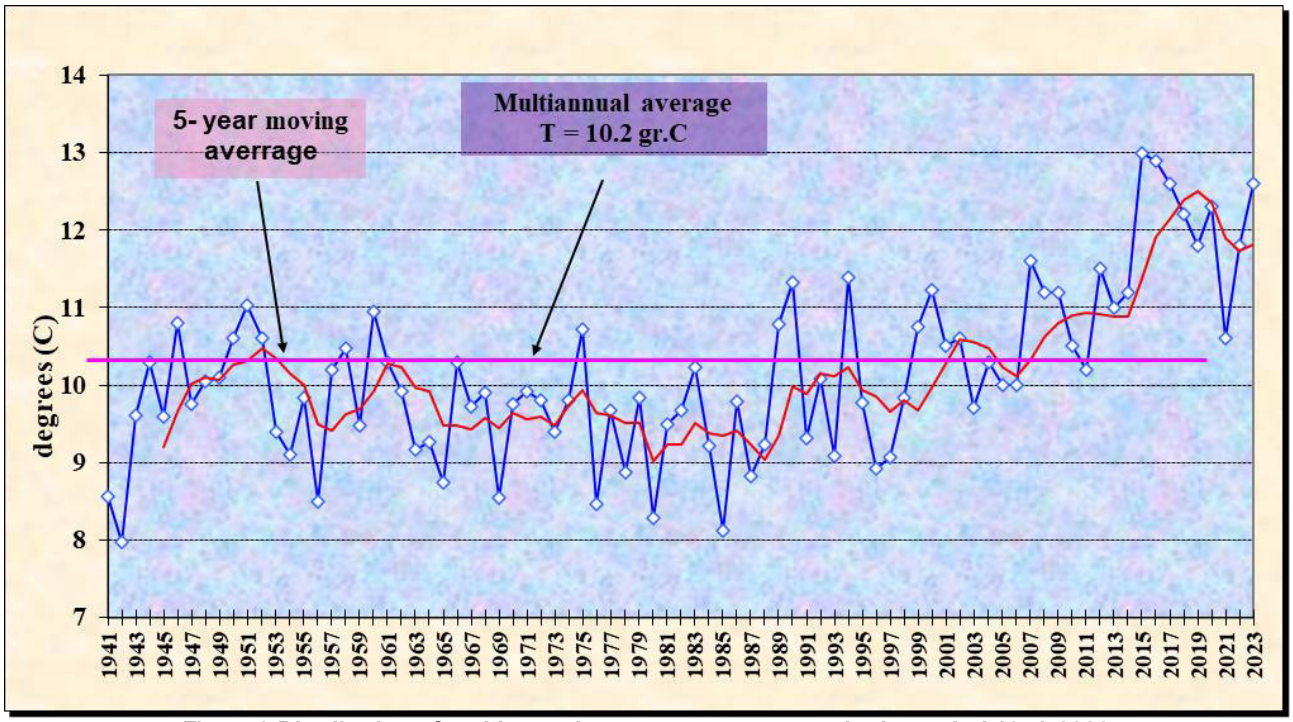

Figure 2 **Distribution of multiannual average temperatures in the period 1941-2023**

In order to have an overview of the evolution of wheat production, *table 1* presents the results obtained during the period 2013-2023.

In the monoculture of wheat, fertilizers are the only added factor, their influence was decisive in determining the production, so if in the non-fertilized variant an average production of 1478kg/ha was obtained, in the other variants the production recorded increases between 286 kg/ha and 1326 kg/ha. Statistically very significant assured production increases were recorded in the $N_{96}P_{96}$ and $N_{128}P_{128}$ variants.

The average production of wheat following the application of manure was 1764 kg/ha higher than the control 119%.

In the two-year wheat-maize rotation, the production differences between the non-fertilized and fertilized variants were higher than those obtained in monoculture. The average production obtained in the non-fertilized version was 1200

kg/ha, approximately 247 kg/ha lower than in the monoculture.

Average productions over the analyzed years in the fertilized variants were between 1441 kg/ha and 3869 kg/ha, 120%-322% higher than the unfertilized control. Statistically very significant assured production increases were recorded in the $N_{96}P_{96}$ and $N_{128}P_{128}$ variants.

In the three-year rotation, where wheat follows after peas, it is found that fertilizers, both chemical and organic, increase production with amounts between 155% and 285% higher than the unfertilized control. The average production, obtained in the non-fertilized variant was 1200 kg/ha, approximately 247 kg/ha lower than in the monoculture, it should be noted that the $N_{128}P_{128}$ variant had the highest increase (4591 kg/ha). It should be noted that all variants registered very significant production increases, statistically ensured both with respect to the error and the interaction with the years.

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Table 1

The effect of the interaction of the wheat crop and the level of fertilization on the production obtained in the years 2013 -2023

Crop rotation	Variant	Production/repetitive (kg / ha)					Average kg/ha	Difference as compared to the control variant	Significance
		1	2	3	4	5			
A1- Monoculture	b_1 (N_0P_0)	596	1597	3460	1399	1766	1478	0	
	b_2 ($N_{32}P_{32}$)	1083	2358	2443	1894	1838	1923	445	***
	b_3 ($N_{96}P_{96}$)	1888	2212	3634	3379	2901	2803	1325	* * *
	b_4 ($N_{128}P_{128}$)	2158	3780	3160	3065	1859	2804	1326	* * *
	b_5 (g.g)	543	1876	1854	1138	1981	1764	286	*
A2- 2 year rotation	b_1 (N_0P_0)	1205	890	1176	1277	1454	1200	0	
	b_2 ($N_{32}P_{32}$)	2473	2555	1990	2235	2744	2399	1199	* * *
	b3($N_{96}P_{96}$)	3961	3790	3573	3448	3625	3679	2479	* * *
	b_4 ($N_{128}P_{128}$)	4274	4432	3838	4006	2797	3869	2669	* * *
	b_5 (g.g)	1191	1418	1436	1404	1754	1441	240	*
A3- 3 year rotation	b_1 (N_0P_0)	1429	1776	1633	1373	1854	1613	0	
	b_2 ($N_{32}P_{32}$)	2937	3205	2144	2542	2825	2731	1118	* * *
	b_3 ($N_{96}P_{96}$)	4559	5151	4722	3659	4242	4467	2854	* * *
	b_4 ($N_{128}P_{128}$)	4789	5176	5042	3977	3972	4591	2978	* * *
	b_5 (g.g)	2076	2809	2378	2021	3255	2508	895	* * *
A5- 5 year rotation	b_1 (N_0P_0)	2126	1772	1632	2149	1485	1833	0	
	b_2 ($N_{32}P_{32}$)	3591	2890	2785	3344	2867	3095	1263	* * *
	b_3 ($N_{96}P_{96}$)	5259	4286	4559	4875	4895	4775	2942	* * *
	b_4 ($N_{128}P_{128}$)	5202	5244	4804	5781	5333	5273	3440	* * *
	b_5 (g.g)	2413	2818	2184	2595	1920	2386	553	* * *

DL 5 % 228 (kg / ha)
DL 1 % 308 (kg / ha)
DL 0,1 % 390 (kg / ha)

Cultivation of wheat in a five-year rotation with spring soil, where pea is the precursor in the rotation, led to productions between 2386 kg/ha and 5273 kg/ha, with increases compared to the control between 130%-288 %. The most significant increase in production was recorded in the version with $N_{128}P_{128}$. The influence of the preceding crop (leguminous for grains) combined with the long period after which wheat returns to the same surface, determined the obtaining of yields clearly superior to the other types of rotation, which means that the wheat crop, as expected, responds with significant increases in production, the employment in which it is included.

The influence of the interaction between crop rotation and fertilization (as a multi-year average over all five fertilization levels) on wheat production can be distinguished from the data in *table 2*, where it is observed that the gains obtained vary between 117%-161%.

Cultivation of wheat in simple rotation with maize brings an increase of 240 kg/ha, in the two-year rotation when wheat follows maize, the average production is higher than in monoculture. Only the five-year rotation brings an increase in production (3472 kg/ha, respectively 161% more than the two-year rotation, *figure 3*).

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Table 2

The influence of crop rotation on wheat production 2013-2023

Crop rotation	Average	Difference as compared to the control variant		Significance	Limit difference	
	kg/ha	%	kg/ha			
Monoculture	2154	100	0			
2 year rotation	2518	117	363	**	DL5%	546
3 year rotation	3182	148	1027	* *	DL1%	766
5 year rotation	3472	161	1318	* * *	DL0.1%	1081

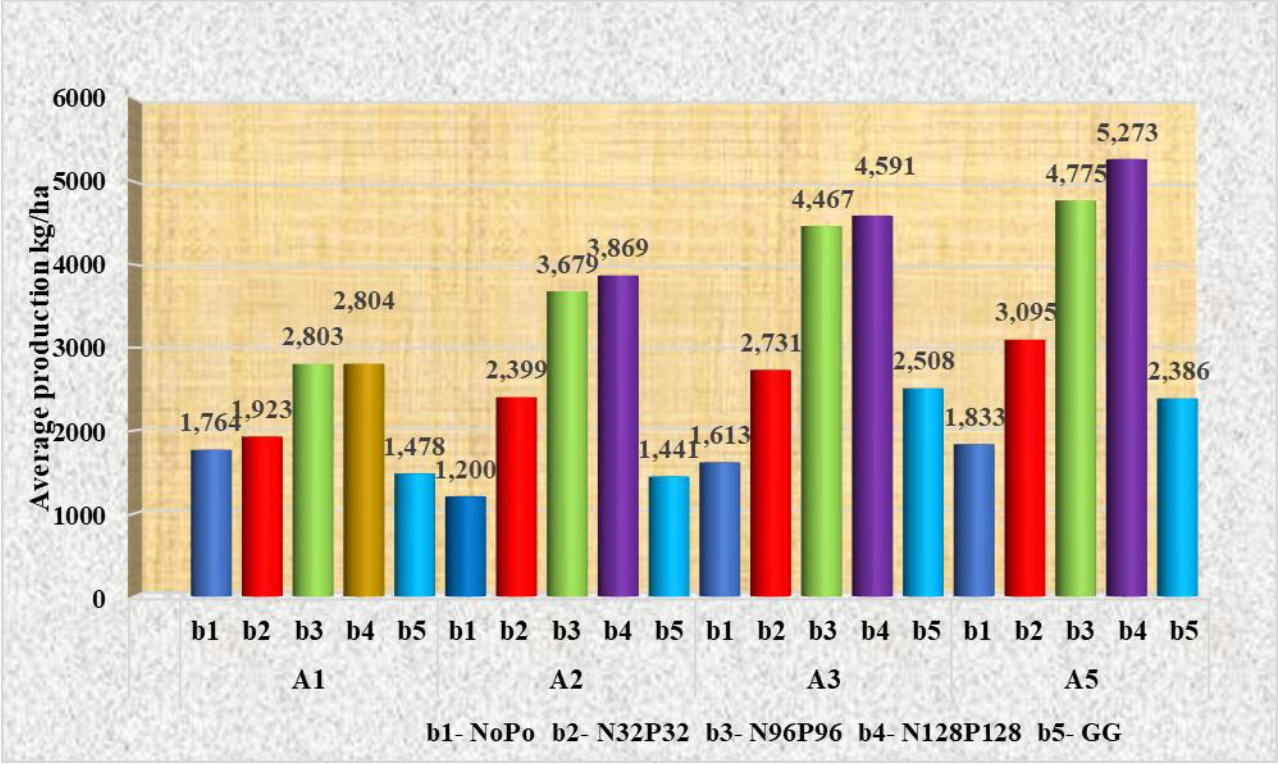

Figure 3 **Dynamics of average wheat production 2013-2023**

CONCLUSIONS

The change in the regime and amounts of precipitation, as well as the increase in the average annual temperature, influenced the level of wheat production in the last 10 years, on the sloping lands, located in the studied area. The uneven distribution in time and space of precipitation during the growing season of crops greatly influenced the growth and development of plants, but also the quality and quantity of production.

Wheat production was also affected due to high temperatures over a long period of time, which led to a prolonged atmospheric drought.

Analyzing the average productions of the wheat crop in crop rotations, in the last 10 years the following was found:

In the wheat crop:

- in monoculture the average production recorded was 2804 kg/ha in the $N_{128}P_{128}$ variant compared to the control variant where a production of 1478 kg/ha was recorded;

- in the 2-year rotation, the average production recorded was 3869 kg/ha in the $N_{128}P_{128}$ variant compared to the control variant where a production of 1200 kg/ha was recorded;

- in the 3-year rotation, the average production recorded was 4591 kg/ha in the N128P128 variant compared to the control variant where a production of 1613 kg/ha was recorded;

- in the 5-year rotation, the average production recorded was 5273 kg/ha in the $N_{96}P_{96}$ variant compared to the control variant where a production of 1833 kg/ha was recorded.

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