Influence of weather conditions on the value of productivity in the sunflower crop

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ABSTRACT: In the Republic of Moldova, the sunflower is becoming a crop more and more often cultivated by farmers, having part of an environment favorable to the development on large areas of our country, however, certain meteorological situations can favor or, on the contrary, restrain the development of this crop. Thus, ensuring food security requires a stable development of agriculture by substantially increasing the degree of evaluation and capitalization of available agroclimatic resources. Climatic factors significantly influence the growth and development of the sunflower culture. The biggest effects on the production capacity are the temperature and the amount of precipitation. Thus, the contribution of meteorological factors in the climatic variability of the harvest value was determined as a correlation between the productivity value and the thermal and humidity regime using the multiple regression equation. Finally, a correlation coefficient (r) was obtained that indicates the contribution of each factor in the formation of the productivity value, the calculated error is 0.01, which allows us to ascertain the close connection between the meteorological factors and the productivity of the given crop.

KEY WORDS: sunflower crop, correlation coefficient, growth, temperature, precipitation.

1. Introduction

The considerable dependence on meteorological conditions determines that agriculture is the most vulnerable sector of the economy of the Republic of Moldova to climate changes, which in turn are one of the main causes of unstable harvests and present an inherent risk for its practice.

The sunflower is becoming a crop more and more often cultivated by farmers, having part of an environment favorable to the development on large areas of our country, but nevertheless certain meteorological situations can favor or, on the contrary, restrain the development of this crop. Thus, ensuring food security requires a stable development of agriculture by substantially increasing the degree of evaluation and capitalization of available agroclimatic resources (Bălănuţă, 1998; Gai et al., 2020; Kremen and Miles, 2012; Jocković et al., 2019).

Cultivation of this plant is profitable, or the sunflower culture has a wide spectrum of uses, by processing the sunflower kernel you can obtain flour, protein concentrates (70 % protein) and protein isolates (85-90 % protein), being at the same time a melliferous plant (Duca et al., 2015; Harbo et al., 2022; Pilorgé, 2020). The production potential is quite high, the demand for sunflower oil is high, and the technology of its cultivation is fully mechanized, so there are no problems for the farmers who cultivate it.

The pedo-climatic conditions of the Republic of Moldova are quite favorable for obtaining high yields of this crop. After the replacement in cultivation technologies of varieties with high productivity hybrids, the global production of the sunflower increased by more than 5 q/ha.

The biological potential of sunflower varieties and hybrids approved and cultivated in the Republic of Moldova is quite high, but unfortunately, the realization of this potential is not at that level. The reasons are many and different, but one of the most convincing would be the fact that the degree of provision of the necessary environmental elements is different from year to year.

The last-minute evaluations of the climatic conditions demonstrate some fairly pronounced oscillations over the years in terms of the amount of atmospheric precipitation and their distribution during the vegetation period, which differentially influences the yield of this crop (Cojocari, 2014, 2015; Croitoru, 2020; Potop, 2011, 2102).

2. Study area

The elaborated conclusions as well as the actual analysis were carried out for the entire territory of the Republic of Moldova. The evaluation of the weather-climatic factors was carried out based on the information available at the weather stations (tab. 1) and the analysis of harvest values and productivity was carried out based on the analysis of information on territorial administrative units (fig. 1).

Table 1 The meteorological stations used in the analysis of meteorological elements.

ID	Station	Coordinate X	Coordinate Y
1	Baltata	654654	5213328
2	Balti	571221	5291685
3	Bravicea	608587	5247539
4	Briceni	507578	5355431
5	Cahul	594086	5083565
6	Camenca	625671	5323210
7	Chisinau	640798	5203858
8	Codrii	603350	5218422
9	Comrat	625482	5128976
10	Cornesti	575060	5246449
11	Ceadir-Lunga	643347	5099655
12	Dubasari	660985	5238526
13	Falesti	552636	5270229
14	Leova	598505	5149114
15	Ribnita	651696	5292945
16	Soroca	597538	5339143
17	Stefan-Voda	703316	5156114
18	Tiraspol	701889	5189677

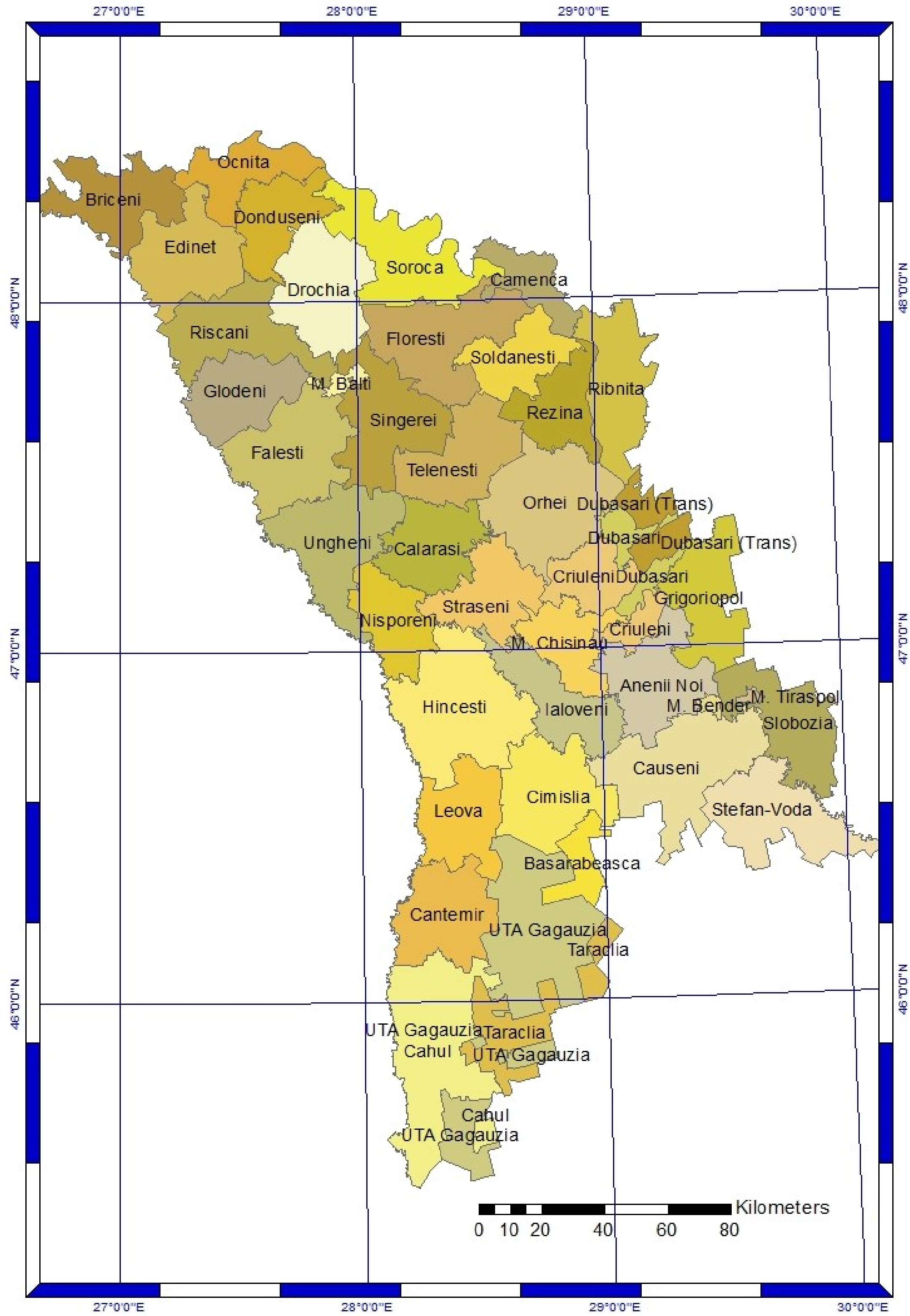

Figure 1 The territorial administrative units of the Republic of Moldova.

3. Methods and materials

The quantification of the contribution of each meteorological factor was carried out by using the regression analysis which assumed obtaining the relationships, in our case linear, between the dependent variable (the value of the productivity of the sunflower crop, q/ha) and the independent variables (the meteorological factors).

The informational base created for a period of 62 years (1960-2022) was constituted by the data on the thermal and pluviometric regime elaborated on the basis of multi-year data collected from 18 meteorological stations subordinated to the State Hydrometeorological Service.

The informational base regarding the productivity of the sunflower crop also constituted 62 years, but in the analysis, 2 antipoise years were taken both from the point of view of the meteorological parameters and the productivity values. In the first case, 2007 was an unfavorable year and 2008 was an optimal year for sunflower cultivation. The evaluation of the direct impact of the metrological elements was carried out using the coefficient of variation determined according to the formula:

$$Cv = \frac{\sigma}{y}$$

where Cv- the coefficient of variation (climatic component), σ- the average standard deviation of the harvest, y – the average value of the de facto harvest.

Studies related to the evaluation of the impact of agroclimatic conditions on the value of the harvest are also included in the works (Vicente et al., 2010; Lobell and Burke, 2008).

4. Results and discussion

The provision of crops with environmental factors is determined not only by the agro-pedological and environmental conditions, but also by the mutual interaction of the concrete plant in the sowing, by the existing competition for light, heat and humidity.

The natural spreading area of the sunflower is contained in the dry area of the prairies of North America, and the homologation process allowed its transformation into a highly productive oleaginous crop of the steppe and forest-steppe areas (with a continental climate), which are characteristic high temperatures and low air humidity in the warm period, the manifestation of the drought phenomenon, determined by increased evaporation against the background of small amounts of precipitation.

Thus, the contribution of meteorological factors in the climatic variability of the harvest value was determined as a correlation between the productivity value and the thermal and humidity regime using the multiple regression equation. Finally, a correlation coefficient (r) was obtained (tab. 2) that indicates the contribution of each factor in the formation of the productivity value, the calculated error is 0.01, which allows us to ascertain the close connection between meteorological factors and the productivity of the given crop.

The obtained values allow us to highlight the following particularities: the influence of one and the same factor in different months (which often correspond to a certain ontogenetic phase) is different. For example, the amount of precipitation that fell in June has a much greater importance in forming the value of productivity compared to their amount in September. Ontogenetically, in these periods the sunflower is in the seed filling phase (month VI) and a higher amount of precipitation will favor a more significant growth and filling of the seed thus determining higher productivity values. Precipitation in September (the period when full ripening takes place) causes losses in the value of the harvest because the colotidium absorbing water "leans", thus favoring the fall of the seeds.

Table 2 Values of the productivity correlation coefficient - meteorological parameter.

Meteorological factors	**The correlation coefficient**	**Meteorological factors**	**The correlation coefficient**
April		**July**	
Medium temperature	0.5532	Medium temperature	**0.9555**
Decade I	0.5486	Decade I	0.5241
Second decade	0.5358	Second decade	**0.9033**
The third decade	0.5452	The third decade	0.6220
The absolute maximum	0.4118	The absolute maximum	0.4531
The absolute minimum	0.0973	The absolute minimum	0.0882
Maximum average temperature	0.2193	Maximum average temperature	0.842
Average minimum temperature	**0.8720**	Average minimum temperature	**0.9704**
The amount of precipitation	0.3563	The amount of precipitation	0.3154
May		**August**	
Medium temperature	0.6967	Medium temperature	0.6209
Decade I	0.6884	Decade I	0.5738
Second decade	0.6851	Second decade	0.6139
The third decade	0.7060	The third decade	0.6028
The absolute maximum	0.3923	The absolute maximum	**0.7751**
The absolute minimum	0.6696	The absolute minimum	0.6950
Maximum average temperature	**0.9272**	Maximum average temperature	0.6602
Average minimum temperature	0.5083	Average minimum temperature	0.7773
The amount of precipitation	0.2737	The amount of precipitation	0.2997
June		**September**	
Medium temperature	**0.9317**	Medium temperature	0.7288
Decade I	0.3863	Decade I	0.7271
Second decade	0.0311	Second decade	0.7409
The third decade	0.3806	The third decade	0.7285
The absolute maximum	0.5316	The absolute maximum	0.1335
The absolute minimum	0.0538	The absolute minimum	**0.9245**
Maximum average temperature	0.0831	Maximum average temperature	**0.9291**
Average minimum temperature	**0.8854**	Average minimum temperature	0.1317
The amount of precipitation	**0.9189**	The amount of precipitation	0.2263

Note: the values marked in the table in red correspond to the phases that have a greater impact on the harvest value and are the most informative in the analysis.

The variability in space of the value of the average productivity per hectare as dependent on the meteorological conditions, in the territorial profile, can also be explained by the coefficient of variation (Cv), which for the entire territory of the republic Cv is 0.24, which allows to mention that the Republic Moldova is positioned as an area with stable sunflower harvests.

At the same time, the cartographic modeling of this index in specific years shows a rather large niche of variability. As a case study in the evaluation of "favorable-unfavorable years" in the growth and development of sunflower cultivation, the years 2007 and 2008 served as unfavorable years and correspondingly favorable years from an agroclimatic point of view.

We mention that the average deviations from the trend line of the productivity value in these years were significant (fig. 2 and fig. 3).

In terms of space, the value of productivity was between 2 q/ha in Basarabeasca and 18.4 q/ha in Ocniţa (fig. 2b).

Correspondingly, the Cv value (fig. 2a) is 0.62, positioning the entire territory of the republic within the framework of the region with the most unstable harvests. And in terms of space, there is a difference between an area with stable harvests (0.2) Ocniţa and the most unstable harvests (1.84) Basarabeasca.

The average value of the temperature during the vegetation period April-October was 17.9°C, being 2.1 °C lower than the optimum requirement of the culture and the amount of precipitation was 297 mm or 153 mm less than the optimum necessary for the sunflower.

In 2008, characterized as favorable from an agroclimatic point of view for the growth and development of the sunflower crop, it recorded thermal values of 16.8°C or -3.2°C from the optimal temperature value and 421 mm or by 21 mm less than the optimal amount required.

The minimum harvest value (fig. 3b) is 10.6 q/ha and was recorded in Străşeni, and the maximum 21.4 q/ha is recorded in Sîngerei and Glodeni.

The Cv value oscillates (fig. 3a) within the limits of 0.16 (Sîngerei, Drochia, Glodeni) and 0.32 (Străşeni, Basarabeasca) which allows us to conclude that this year according to the degree of favorability for the development of the sunflower is positioned as a year of stable-relatively stable harvests. As a whole, the territory of the Republic of Moldova corresponds to a value of 0.19, which is characterized as an area with stable harvests.

This explains the variability of the harvest value in rainy years, which are not necessarily more favorable than dry years. The situation is explained by the fact that the evaluation includes other factors that can be even more restrictive than this one.

Therefore, it can be concluded that the variability from one year to the next of the agroclimatic favorability can be quite accentuated, a fact that justifies the usefulness and necessity of completing the favorability analysis at the multiannual average level with an analysis of the interannual variability, in order to have a picture more real on the agroclimatic potential.

Thus, the quantification of the influence of the main meteorological factors, the temperature and the amount of precipitation, on the productivity of the sunflower crop is possible using the analysis of the regression equation, presented previously, and respectively through the analysis of the correlation matrix provided by Screening Design modeling, one of the statistical methods that allows us to the role of independent values (expressed by monthly thermal values and monthly precipitation amounts) is identified in the formation of the "dependent" variable, in our case the productivity value (figs. 4 and 5).

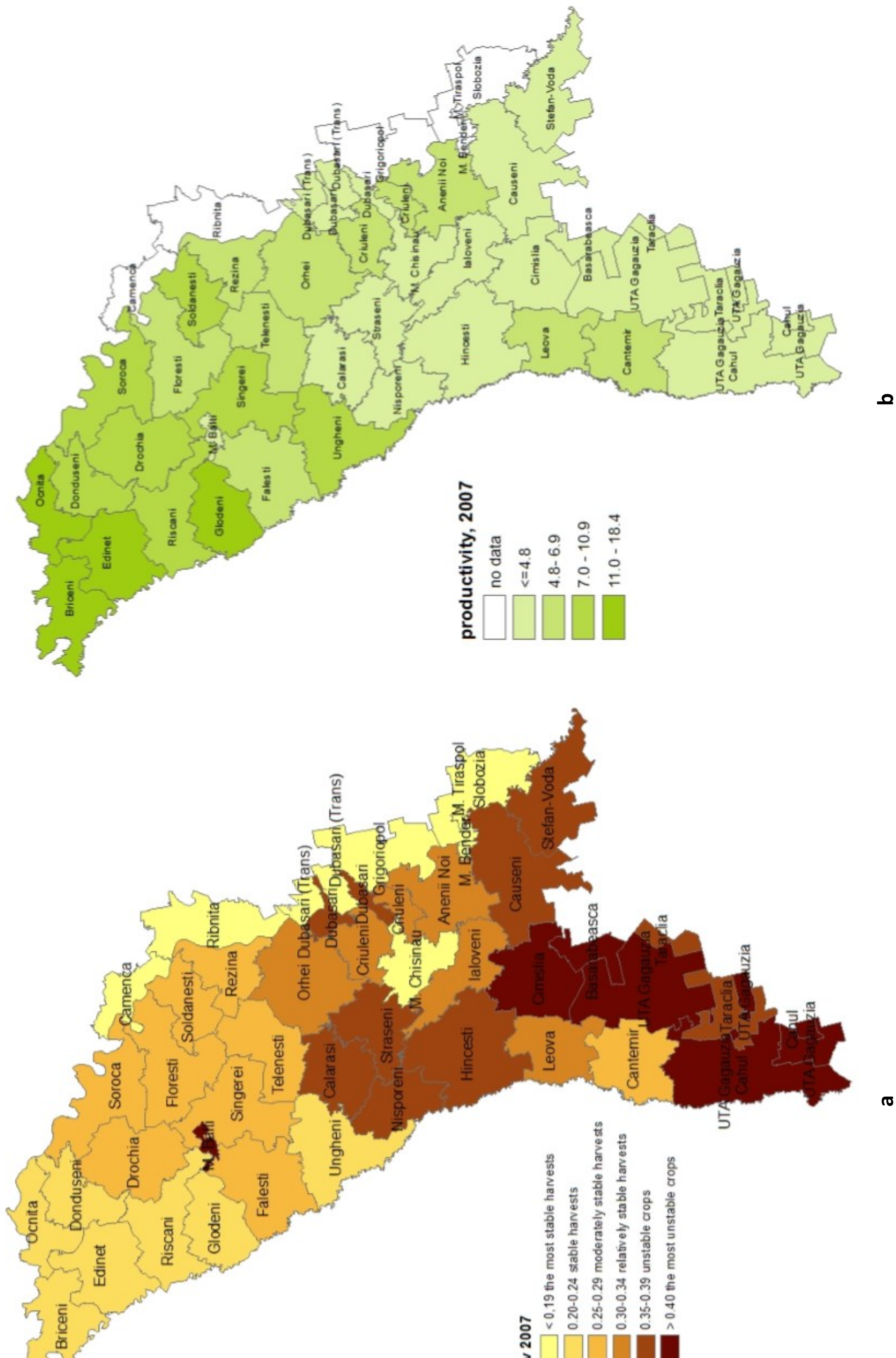

Figure 2 Cartographic modeling of a. the coefficient of variation, year 2007; b. the productivity value for the sunflower crop, year 2007.

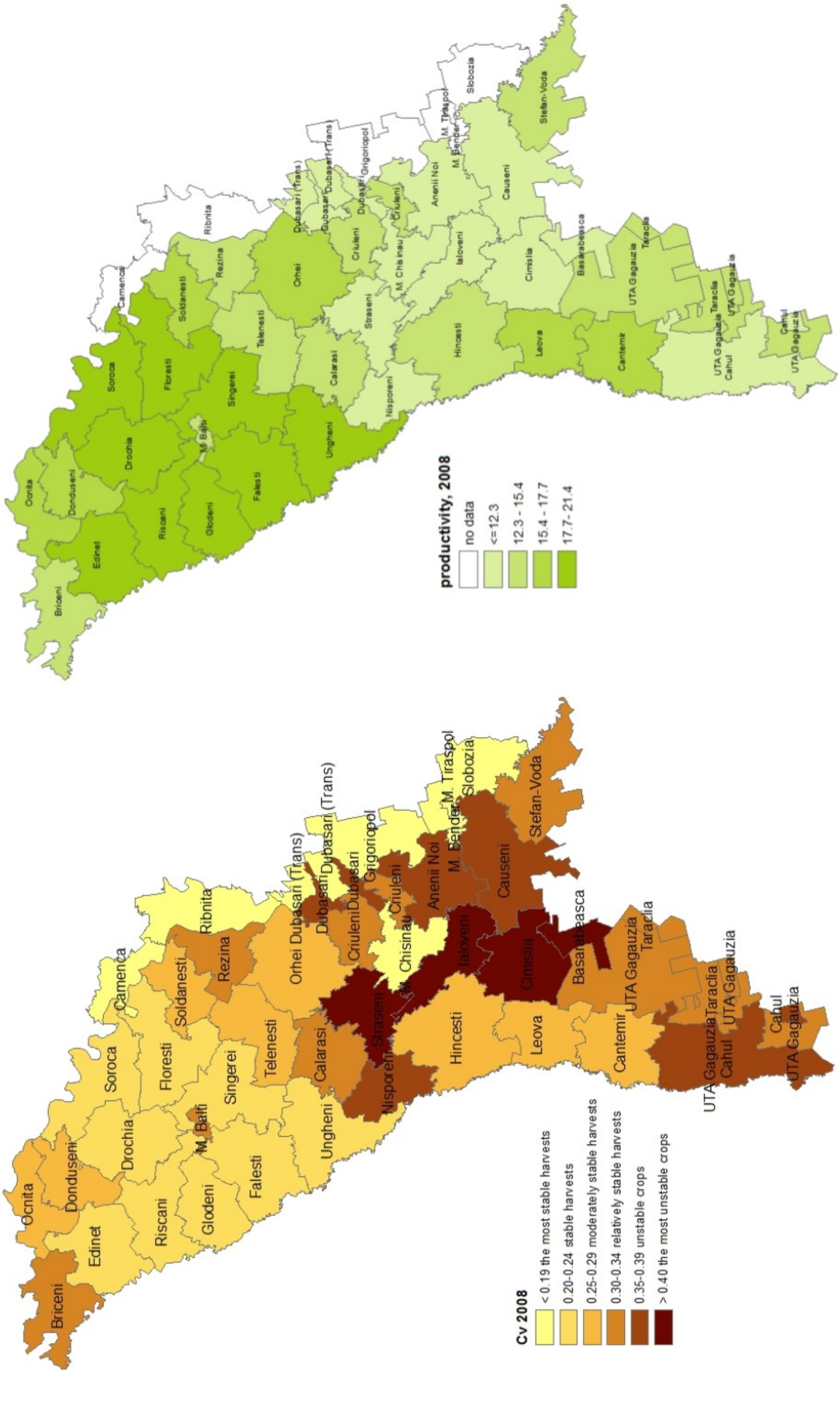

Figure 3 Cartographic modeling of a. the coefficient of variation, year 2008; b. the productivity value for the sunflower crop, year 2008.

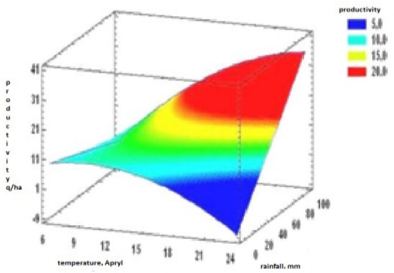

Figure 4 Modeling the productivity value of meteorological conditions in the April.

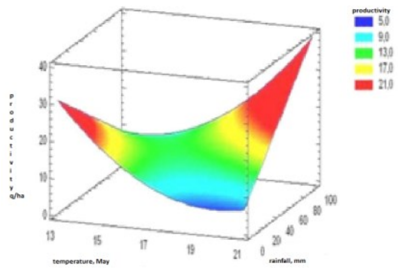

Figure 5 Modeling the productivity value of meteorological conditions in the May.

From the models obtained, we observe that the dependence of the productivity value on the temperature and precipitation values for the month of April, the period when the sunflower crop is sown, is directly proportional. The higher the values of both meteorological parameters (temperature and precipitation), the more premises are created for the formation of high productivity. The same trend is preserved for the month of May, the period when the seedlings appear.

5. Conclusion

In conclusion, we find that the great spatial variability of heat and humidity resources in the context of climate changes determines the need for the correct adaptation of the sunflower to these changes, by revising the crop rotation and by the correct territorial placement of the sowing, taking into account the specifics of the territory of the Republic of Moldova.

The dependence of the productivity value of the sunflower crop on the weather conditions is closely related to the ontogenetic phase.

The most demanding to the thermal factor are the initial phases of emergence, the formation of the seedling, the formation of the second pair of true leaves. The first two being very responsive to the minimum average temperature, the last to the maximum. Correlation coefficients range from 0.5083-0.8720 for minimum temperature and 0.92722.

Starting with the seed formation phase and its filling, a more pronounced need in the amount of precipitation is attested. The correlation coefficient is 0.9189.

Critical for all ontogenetic phases are the maximum values of temperature and insufficient precipitation, a fact also proven by the comparative analysis of Cv with the value of productivity.

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