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# TERRITORIAL DIMENSION OF WHEAT PRODUCTION IN ROMANIA

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**Abstract:** Romania's significant agricultural productive potential can fully cover domestic demand and can ensure important export deliveries. However, the yield of cereal production is below the European Union average. Of these, an important place is occupied by wheat production. Taking into account these aspects, the paper investigates the potential of wheat production in Romanian counties starting from a set of indicators and using cluster analysis to identify similarities and disparities between counties from this point of view. Through this study we tried to provide answers to the questions: What is the configuration of wheat production yield at the regional level in Romania? What is its evolution over time? The results obtained during the research show that there are disparities in the counties of Romania in terms of the efficiency of wheat production in correlation with the resources used for its production.

**Keywords:** agricultural sector, wheat production, production yield, regional development, Romania

**JEL classification:** C10, C38, O13

## INTRODUCTION

Balanced territorial development, including the adoption of rural development measures, embodied in national and regional programs to address the needs and challenges facing rural areas, are major objectives pursued by the Common Agricultural Policy of the European Union (CAP, 2017). In promoting and supporting territorial cohesion, many experts believe that public policies must take into account primarily territorial needs (Sykes & Baing, 2017 and Popescu & al., 2016) even if there is currently no consensus on how this should be done.

The identification of these needs, of the mechanisms necessary for their satisfaction process, must be done by each country (Kruzslcika, 2018), depending on the scale of existing regional disparities, social preferences, division of power in that country, the nature of regional challenges, but also the available financial resources (Trașcă et.al., 2013).

Agricultural products are part of the regional identity due to several factors, among which the most important are the natural environment and climate. The soil and climatic conditions in Romania correspond, to a large extent, to the biological requirements for the cultivation of wheat and, as a result, rich crops of superior quality can be obtained.

Wheat cultivation is a tradition of Romanian agriculture (Soare, 2018), being a basic product in food consumption (bakery wheat) as well as in animal consumption (feed wheat). In Romania, the consumption of wheat and wheat products is higher than the European average, and in terms of wheat production, in 2018, Romania occupied the 4th position in the EU, with 10.27 million tons. The continuous development of agricultural production, and implicitly of wheat, accelerates the process of economic growth, by taking over a part of the value produced by agriculture by other economic branches. (Dospinescu, 2005)

The development of agriculture, implicitly the production of wheat, is determined not only by the natural environment, climate and its changes (Taylor et.al., 2018), but also by other factors, some with negative effect, including: water pollution (Stoica, 2006), soil erosion, air quality,

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pandemics (Zhang, 2020), and others with a positive effect on regional development, such as the development of rural economies driven by the development of rural tourism (Davidescu et.al., 2018).

At the level of the European Union, 10.5 million farms, of which 32.7% located in Romania where registered in 2016 (Eurostat, ef\_m\_farmleg, 2019). At the same time, it should be specified that Romania is on the list of EU countries with the smallest average farm size, measured by standard production, and the Southwest Oltenia region has the lowest standard level of production per farm (EUR 2,710). As for farm managers, over 40.0% of them were over 65, which implies the encouragement of a new generation of farmers.

This article presents a statistic of wheat production at territorial level in Romania, provides information on the territorial dimension of wheat production yield and identifies suitable areas for wheat cultivation using the cluster method.

The article was structured in five sections containing the introduction, the research methodology used in validating the objectives proposed in the research, a section in which the results obtained and the related discussions are presented, and the last part contains the conclusions and references sections.

## RESEARCH METHODOLOGY

The methodology of data collection and analysis was based on two main stages: territorial analysis of the evolution of the weights of cultivated areas with the main cereal crops, with emphasis on wheat production in order to identify areas with potential, and respectively, cluster analysis of similarities and dissimilarities between the 41 counties of Romania considering the wheat production in 2019. In the study, 8 indicators were used, the abbreviations, meanings and units of measurement can be found in Table 1.

Table 1 The main variables used in the analysis of similarities and disparities regarding wheat production at territorial level

Variable	Significations	UM
AWF	Area cultivated with wheat in farms, at county level	ha
AWIF	Area cultivated with wheat in individual farms, at county level	ha
WPF	Wheat production per hectare on farms, at county level	Kg/ha
WPIF	Wheat production per hectare on individual farms, at county level	Kg/ha
SWF	The share of the area cultivated with wheat in farms, in the total area cultivated with wheat, at county level	%
SWIF	The share of the area cultivated with wheat in individual farms, in the total area cultivated with wheat, at county level	%
SCAF	The share of the cultivated area with the main crops in farms, at county level	%
SCAIF	The share of the cultivated area with the main crops in individual farms, at county level	%

An image of the relationships between wheat production and its yield was highlighted by applying a quantitative descriptive method, which is based both on the comparative analysis of the absolute values of the eight indicators, recorded in the counties included in the study, and by highlighting the relationships between these.

The main characteristics of the variables included in the study are presented in Table 2. From their analysis, a first observation concerns the rather high values of standard deviation (Std.Dev) in relation to the average values of the variables AWF and AWIF; this fact is due to the significant differences between the relief forms specific to the counties of Romania. At the same time, for the WPF and WPIF variables that refer to yields per hectare, the coefficients of variation have the values of 14.8% and 16.4% emphasizing the significance of their values. With regard to the other four variables, there are differences between farms and individual farms in terms of the area of cereal-grown areas in total cultivated areas, and of wheat-cultivated areas in total.

Table 2 Descriptive statistics of data series

	AWF	AWIF	WPF	WPIF	SWF	SWIF	SCAF	SCAIF
Mean	27680.41	24948.78	4354.05	4295.15	43.37	56.08	31.30	68.10
Std.Error	4927.20	4365.93	100.78	110.19	3.71	3.72	3.23	3.23
Median	13413.00	15402.00	4211.00	4359.00	41.73	57.12	27.38	72.16
Std.Dev	31549.49	27955.60	645.28	705.54	23.73	23.81	20.67	20.69
Kurtosis	0.34	5.93	-0.61	-0.59	-1.10	-1.10	-0.66	-0.64
Skewness	1.25	2.33	0.23	0.05	-0.09	0.13	0.50	-0.48
Range	104159.00	132286.00	2608.00	2790.00	81.98	81.98	78.08	78.90
Minimum	99.00	3000.00	3196.00	2911.00	1.64	16.38	0.73	20.27
Maximum	104258.00	135286.00	5804.00	5701.00	83.62	98.36	78.81	99.16
Cnf.Lev (95%)	9958.25	8823.88	203.68	222.70	7.49	7.52	6.52	6.53

Source: Developed by authors using SPSS

To analyze the disparities and similarities between the counties of Romania regarding the efficiency and yields of wheat production, it was used the hierarchical clustering analysis. (Johnson, 1967 and D'Andrade, 1978). The cluster analysis was performed against four indicators: area cultivated with wheat in farms, at county level (AWF), area cultivated with wheat in individual farms, at county level (AWIF), wheat production per hectare on farms, at county level (WPF) and wheat production per hectare on individual farms, at county level (WPIF).

Cluster generation was performed using Euclidian distance (Proximity Martix) and Ward Linkage Method. To test the statistical significance of the membership of the variables in the clusters, as well as the average values obtained at the level of each cluster, we used the Levene's test (the variance homoscedasticity test) and the Welch robust tests of equality of means.

For testing the statistical hypotheses on homoscedasticity of variance and on the statistical significance of the average values of the indicators analyzed at the cluster level (tests of equality of means), the significance level used was 95% ( $\alpha = 0.05$ ), and in exceptional cases being allowed and 90% ( $\alpha = 0.10$ ).

## RESULTS AND DISCUSSIONS

The evolution of the weights of the cultivated areas with the main crops by forms of ownership in the period 1990-2019 shows us significant differences between the three forms of ownership, but also their considerable variations during the 20 years. (Figure 1).

At the beginning of the analyzed period, 1990, the largest share of areas cultivated with the main crops was owned by the state (71.64% compared to 28.36% individual farms and 0% farms). This situation changes from the following year, with the start of the privatization process by the adoption of Law no. 15/1990, by which the former state enterprises during the communist regime were transformed into commercial companies or autonomous companies. Thus, at the end of the analyzed period the largest share of areas cultivated with the main crops is found in Individuals farms (59.30%), followed by farms (40.36%), while the state still owns only 0.53%.

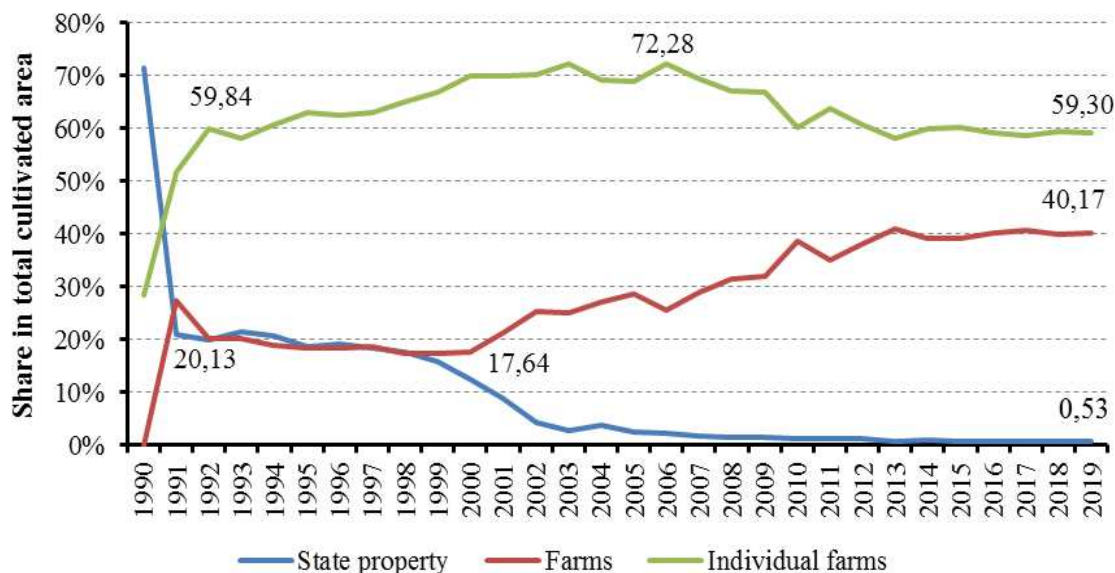


Figure 1 Evolutions of the weights of cultivated areas with the main crops by forms of ownership in the period 1990-2019

In 2019, from the point of view of the counties that have the largest shares of individual farms in the areas cultivated with the main crops, Vâlcea stands out with 99.16% on the first place, then on the second place Gorj county with 98.1% ha, and on the last place is Călărași with 20.27%. (Figure 2)

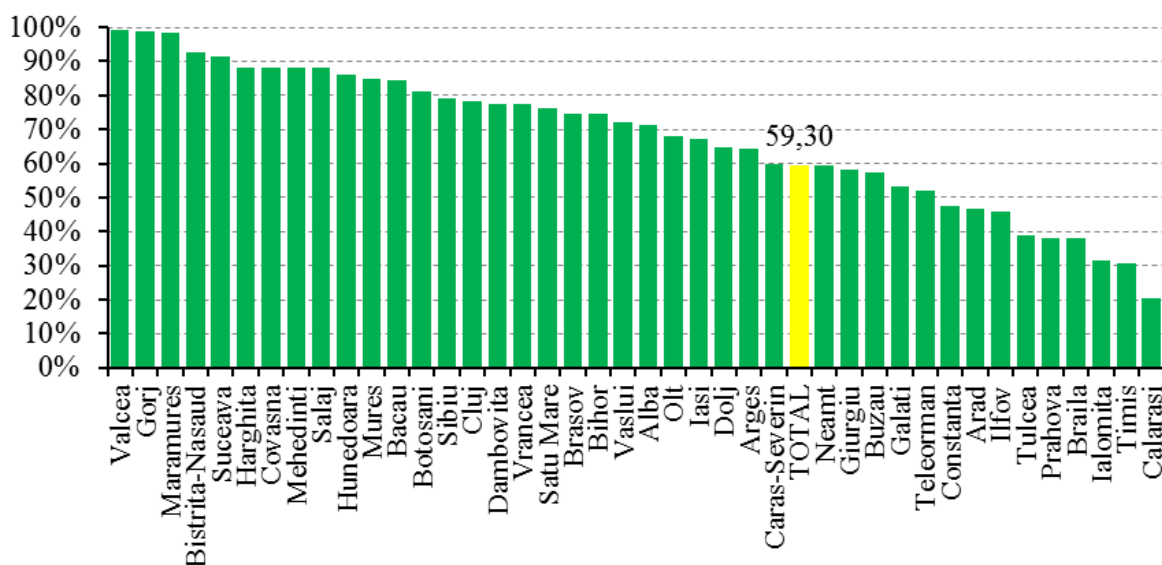


Figure 2 Distribution of individual farms shares in cultivated areas with the main crops at the county level compared to the average value in Romania in 2019

Regarding the average annual evolutions of wheat production per hectare in farms and individual farms in the period 1990-2019, major fluctuations can be observed over short time intervals (2-3 years), and starting with 2012, wheat production, in both forms of ownership, it is on an upward trend until 2018, when we notice a slight decrease. (Figure 3)

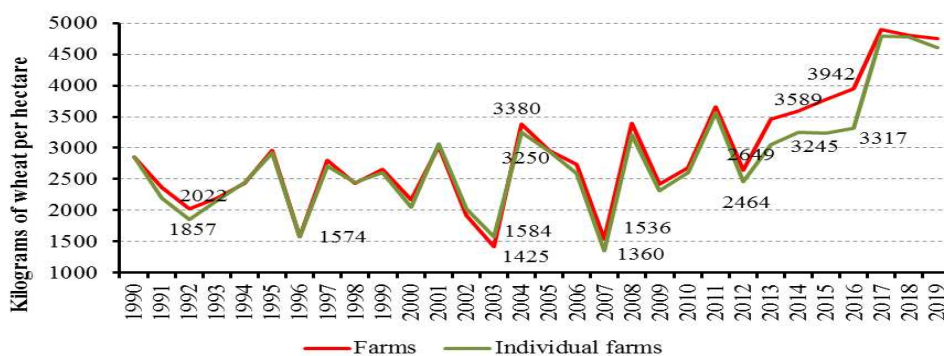


Figure 3 Average annual developments of wheat production per hectare in farms and individual farms in the period 1990-2019

If in 1990, the annual average of wheat production was 3235 kg / ha (by 2861 kg / ha for both types of farms), in 2019 it increased by 98.53%, reaching 4749 kg / ha.

Starting from the four indicators mentioned above (AWF, AWIF, WPF and WPIF), the similarities and disparities between Romania's counties, in terms of wheat production efficiency in farms and individual farms in 2019, were analyzed based on hierarchical cluster methodology, through a hierarchy in five clusters. The Levene test was used to analyze the statistical significance of the mean values at the level of the clusters and to assess the degree of homogeneity of the variance (Table 3).

Table 3 Results of Test of Homogeneity of Variances

	Levene Statistic	df1	df2	Sig.
AWF	10.232	4	36	0.000
AWIF	2.241	4	36	0.084
WPF	.961	4	36	0.441
WPIF	1.737	4	36	0.163

The results obtained after the application of the Levene test show that, for three of the four indicators, at a significance threshold  $\alpha = 0.05$ , the null hypothesis  $H_0$  can be accepted. For the indicator "Area cultivated with wheat in farms, at county level" with Sig. = 0.00  $< \alpha = 0.05$ , the null hypothesis  $H_0$  must be rejected and, consequently, the ANOVA methodology cannot be applied.

To test the equality of the averages, starting from the premise that there is no homogeneity of the variance of the four indicators in the clusters and the fact that the groups do not have equal dimensions, the Welch and Brown-Forsythe tests were used. According to them, the statistic is significant at the level of 0.05 and the null hypothesis that the groups have equal averages is rejected.

Table 4 Results of Robust Tests of Equality of Means

	Statistic <sup>a</sup>	df1	df2	Sig.	
AWF	Welch	20.203	4	11.804	0.000
	Brown-Forsythe	27.532	4	10.680	0.000
AWIF	Welch	12.107	4	11.714	0.000
	Brown-Forsythe	22.878	4	7.635	0.000
WPF	Welch	47.405	4	12.397	0.000
	Brown-Forsythe	36.332	4	21.308	0.000
WPIF	Welch	45.208	4	12.139	0.000
	Brown-Forsythe	23.922	4	13.159	0.000

Asymptotically F distributed.

The results of the Welch and Brown-Forsythe tests show that, for all four indicators analyzed, all Sig.F values are less than  $\alpha = 0.05$ , so the null hypothesis  $H_0$  is rejected and, consequently, the averages differ significantly. Thus, the test results show that the cluster membership of the 41 counties of Romania is statistically significant and is presented in Table 5.

Table 5 Clusters structure

Cluster	Counties
C_1	Bihor, Buzau, Galati, Dambovita, Prahova, Ilfov, Valcea, Caras-Severin
C_2	Bistrita-Nasaud, Maramures, Satu Mare, Brasov, Harghita, Sibiu, Botosani, Iasi, Neamt, Suceava, Vaslui, Vrancea, Arges, Gorj, Mehedinti, Hunedoara
C_3	Cluj, Salaj, Alba, Covasna, Mures, Bacau
C_4	Braila, Tulcea, Calarasi, Giurgiu, Ialomita, Arad, Timis
C_5	Constanta, Teleorman, Dolj, Olt

Most counties are included in the second cluster (C\_2), respectively 16 counties which represent 39.02% of the total of 41 counties analyzed. Next, in the first cluster (C\_1) are included 8 counties, then in the fourth cluster (C\_4) there are 7 counties, the third cluster (C\_3) is composed of six counties, so that in cluster five (C\_5) there are only 4 counties.

The characteristics of the Romanian county clusters, from the point of view of wheat crops at the level of 2019, are highlighted mainly through their classification in relation to the determined average values. The descriptive statistical parameters and the characteristics associated to each cluster in terms of the analyzed indicators are presented in table 6.

Table 6 Characteristics of Romanian county clusters in terms of wheat crops in 2019

Cluster	Variable	Mean	Std. Deviation	Std. Error	Lower Bound	Upper Bound
1	AWF	19834.00	12006.45	4244.92	9796.36	29871.64
	AWIF	17467.38	17753.67	6276.87	2624.94	32309.81
	WPF	5238.88	314.87	111.32	4975.64	5502.11
	WPIF	5252.50	340.13	120.26	4968.14	5536.86
2	AWF	8645.13	8526.51	2131.63	4101.67	13188.58
	AWIF	12971.50	9213.82	2303.45	8061.80	17881.20
	WPF	4141.50	281.72	70.43	3991.38	4291.62
	WPIF	4132.00	335.80	83.95	3953.07	4310.93
3	AWF	5083.83	2759.33	1126.49	2188.09	7979.58
	AWIF	11464.17	6974.85	2847.47	4144.52	18783.82
	WPF	3417.17	179.07	73.11	3229.24	3605.09
	WPIF	3210.33	202.37	82.62	2997.96	3422.70
4	AWF	72681.00	24634.97	9311.14	49897.45	95464.55
	AWIF	31376.86	9910.84	3745.95	22210.86	40542.86
	WPF	4325.86	391.60	148.01	3963.69	4688.02
	WPIF	4358.14	449.01	169.71	3942.88	4773.40
5	AWF	74658.25	23658.43	11829.21	37012.41	112304.09
	AWIF	96798.50	26928.47	13464.24	53949.29	139647.71
	WPF	4889.25	309.06	154.53	4397.47	5381.03
	WPIF	4550.00	544.43	272.21	3683.69	5416.31

Taking into account with priority both the average values of wheat areas and productions, as well as the confidence intervals (Lower and Upper Bound), it is important to highlight the oscillation of these indicators by counties, at the level of each cluster.

A cluster analysis of the area cultivated with wheat in farms (AWF) places on the first place Constanța county with 104258 ha from C\_5, then Arad with 97380 ha component of C\_4, followed

by Buzău with 34870 ha from C\_1, then Argeş with 25196 ha belonging C\_2 and Mureş with 8195 ha in C\_3. The smallest AWF areas are noticed in C\_5 with Olt county through the 49,407 ha, then in C\_4 with Giurgiu county (36009 ha), followed by C\_3 through Sălaj county (1584 ha), by C\_1 through Vâlcea county (184 ha) and C\_2 at the level of Maramureş county through the 99 ha.

In relation to these distributions by counties and clusters of AWF and the production of wheat per hectare of farms (WPF) should have a similar evolution. However, the situation is different, the oscillations at the level of each cluster being: at C\_1 between 4746 kg / ha obtained in Galati county and 5804 kg / ha in Dâmboviţa, for C\_2 between 3714 kg / ha (Vrancea) and 4661 kg / ha (Sibiu) , then at C\_3 the minimum production belongs to Mureş county with 3196 kg / ha, and the maximum to Covasna county with 3695. For C\_4 the WPF variation is between the minimum of 3879 kg / ha in Brăila and the maximum of 4947 kg / ha in Ialomiţa, while, at the level of cluster C\_5, Dolj county has the lowest production of 4598 kg / ha, and Constanţa county has the highest production of 5237 kg / ha.

Regarding the AWIF indicator, it can be specified that the largest areas are in the counties of Dolj from C\_5 (135286 ha), Bihor from C\_1 (58641 ha), Giurgiu from C\_4 (48091 ha), Mehedinţi from C\_2 (36835 ha) and Covasna from C\_3 (21528 ha). The smallest areas for wheat cultivation at the level of individual farms are 76816 ha and are found in Constanţa from C\_5, then 15278 ha in Brăila from C\_4, followed by 5185 ha in Sălaj from C\_3, 3088 ha from Caraş-Severin of C\_1, respectively 3000 ha from Maramureş belonging to cluster C\_2.

The production situation corresponding to these areas (WPIF) highlights Ilfov county with a maximum of 4857 kg / ha and Caras-Severin with a minimum of 5701 kg / ha for C\_1, then Hunedoara with a production of 3677 kg / ha, respectively Argeş and Sibiu both with a minimum of 4601 kg / ha for C\_2. In C\_3 the production oscillates between 2911 kg / ha (Sălaj) and 3512 kg / ha (Alba), then in C\_4 the counties of Călăraşi with 3580 kg / ha and Arad with 4820 kg / ha represent the extremes of production, while for C\_5 the highest production belongs to Teleorman county (4991 kg / ha) and the smallest to Dolj county (3756 kg / ha).

## CONCLUSIONS

Assessing the territorial dimension of wheat production is very important in order to adopt measures that meet the needs of society and correctly identify the actions that are required to increase its yield.

The research aimed at two complementary objectives, on the one hand highlighting an image of the evolution of wheat production in the last 20 years, and on the other hand, identifying the best performing counties in Romania in terms of wheat production. The results of the study highlight a series of disparities in wheat production at the territorial level in Romania.

In 2019, cluster 1 (C\_1) recorded the highest average values for two of the four indicators, the component counties are located in eastern and southern Romania (except Bihor - west), presenting the highest wheat production per hectare in Romania. This cluster, compared to the other four, ranks third through the average areas of the component counties (AWF and AWIF). Cluster 5 (Constanta, Teleorman, Dolj, Olt) is in the top of the ranking in terms of average values of the other indicators (AWF and AWIF), because it includes mainly the counties in southern Romania that have the largest areas cultivated with wheat. At the same time, due to the large cultivated areas and the very favorable climate, this cluster ranks second with the respective counties in terms of production per hectare for both general and individual farms (WPF and WPIF), a fact noted by the average values obtained. Although the second cluster (C\_2) includes most counties (Bistrita-Nasaud, Maramures, Satu Mare, Brasov, Harghita, Sibiu, Botosani, Iasi, Neamt, Suceava, Vaslui, Vrancea, Arges, Gorj, Mehedinti, Hunedoara ), they are not representative for wheat cultivation. This statement is supported by the average values of both cultivated areas and production per hectare, which places C\_2 only in fourth place, compared to other clusters that have fewer counties. A similar situation is registered for cluster three (C\_3) which, although it is composed of only six counties (Cluj, Salaj, Alba, Covasna, Mures, Bacau), the average values of all four indicators are so



low that it will occupy last place in the rankings. Regarding cluster four (C\_4) we can highlight the second place in terms of average values of areas cultivated with wheat (AWF and AWIF) and the third place for the yields obtained (WPF and WPIF).

Wheat production per hectare of farms in general but also of individual ones (WPF and WPIF) is distributed differently by counties at the level of each cluster compared to that of AWF and AWIF areas. This aspect reflects the fact that, regardless of the cultivated area, attention must be paid to the level of each farm, of each county regarding the cultivation and treatment methods applied, having a significant impact on the production obtained.

In the context in which wheat production, as a priority component of agriculture, faces significant disparities at territorial level, it is possible to mention the need to develop policies to support socio-economic development. In this direction, the priorities are: ensuring irrigation, applying efficient methods and techniques of cultivation, treatment and harvesting, attracting investments.

The research topic is open for further exploration, extension, and refinement in a future project. Thus, the authors consider that an analysis correlated with wheat production with the climatic and natural conditions specific to each county and the applied agricultural policies can lead to the identification of the causes that generate regional disparities in wheat production.

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