Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development
Vol. 23, Issue 2, 2023
PRINT ISSN 2284-7995, E-ISSN 2285-3952

THE VARIABILITY AND INFLUENCE OF PRECIPITATION ON THE WINTER WHEAT IN THE EXTRA-CARPATHIAN AREA OF THE MERIDIONAL AND CURVATURE CARPATHIANS (ROMANIA)

Dana Maria (OPREA) CONSTANTIN[1], Nicoleta IONAC[1], Elena GRIGORE[1], Giorgiana Daiana LÜFTNER[2, 3], Raul Gabriel ILEA[2, 3]

[1]The University of Bucharest, The Faculty of Geography, 1 Nicolae Balcescu Avenue, 010041, District 1, Bucharest, Romania, Email: danamartines@yahoo.com, ionac.nicoleta@geo.unibuc.ro, elazigzag@gmail.com
[2]The University of Bucharest, The Faculty of Geography, Doctoral School ”SimionMehedinți”, 1 Nicolae Bălcescu Avenue, 010041, district 1, Bucharest, Romania, Email: giorgiana.luftner@gmail.com, raul11_bv@yahoo.com
[3]National Meteorological Administration, 97 București-Ploiești Street, 013686, Bucharest, Romania.

Corresponding author:danamartines@yahoo.com

Abstract

The annual variability of the climatic factors is reflected in the variability of the agricultural yields from one year to another and the analysis of the impact of climate variability on agricultural crops can facilitate the adoption of measures to prevent, mitigate or combat the damage it causes to agriculture. The main objective of this study is to analyze the precipitation regime for the Extra-Carpathian area of the Meridional and Curvature Carpathians, in relation to the optimal water precipitation requirement of the winter wheat. The analysis of precipitation variability will be based on the monthly precipitation amounts from 19 meteorological stations (M.S.) belonging to the National Meteorological Administration, for the period 1991 – 2020. The methods used are logical, spatial and comparative analyses of the climate and production data, literature research and GIS techniques. The annual precipitation amounts, for the analyzed period, have recorded values ranging from 727.7 mm atRâmnicu Vâlcea M.S. to 240.5 mm at Sulina M.S.As it concerns the winter wheat crop productivity, the values of the yields varied from 1,429kg/ha to 4,888 kg/ha in the study area. The conditions closer to or further away from optimum requirements and thus, a variability of harvests from a year to another are provided by the great variability of precipitation along with other climatic factors which influence the growth and development of winter wheat. As a result, the precipitation regime is a determining factor for the entire plant physiology.

Key words**:** *precipitation, climate variability, winter wheat, yields,Extra-Carpathian area*

INTRODUCTION

The winter wheat, like any cultivated plant, has certain bioclimatic requirements, which influence the vegetative processes and crop productivity. These bioclimatic requirements are in relation to the main climatic factors: light, temperature and precipitation [13]. The annual fluctuation of the climatic factors determines the variability of yields from one year to another [11]. The analysis of the climate variability on vegetation and agricultural production is the basic criterion for adopting measures to prevent, mitigate or combat the damage it causes to agriculture. The objective of this study is to analyze the variability of the precipitation regime from 1991 to 2020 and its influence on the winter wheat crop and yields.

The common wheat is the most important species, both worldwide and in most of the cultivated area in Romania, representing 90% of the cultivated area [10]. The varieties of common wheat are the spring wheat and winter wheat cultivated on about 99% of Romania's arable land [6].

In the transitional temperate continental climate [7] characteristic of the territory of Romania, the winter wheat is cultivated as a rainfed crop [9]. The winter wheat has a vegetation period of 230 to 250 days, being mainly influenced by the pedoclimatic conditions, but also by the cultivated variety [15].

Precipitation is the main source of water for the growth and development of the agricultural crops [5, 15]. The precipitation regime on the territory of Romania is characterized by a great variability and discontinuity in time and space [1]. In the context of the present global warming, the ability to objectively evaluate the water resources required for an agricultural crop are offered by the analysis of the precipitation regime.

The study area where is analyzed thevariability and influence of precipitation on winter wheatis the Extra-Carpathian area of the Meridional and Curvature Carpathians. It corresponds to very favorable and favorable areas for the cultivation of winter wheat [14] especially represented by the Romanian Plain, the Getic Plateau and the Dobrogea Plateau (Fig. 1). From administrative point of view, the study area overlaps most of the Economic Development Regions: the South-West Oltenia, the South Muntenia, Bucharest-Ilfov and the South-East.

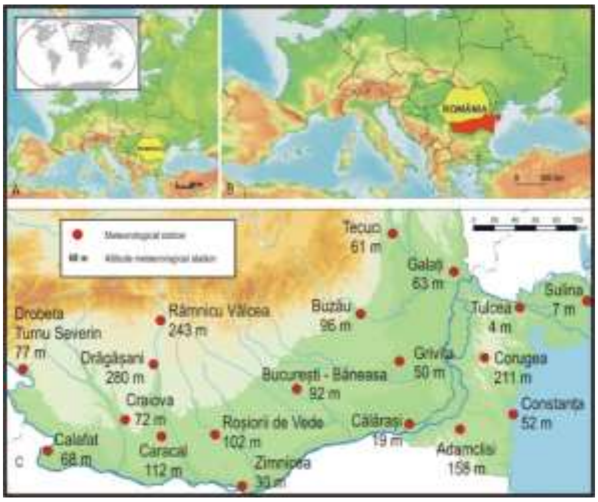

Fig. 1. The location of the study area and of the meteorological stations.
Source: own processing from GIS open sources.

MATERIALS AND METHODS

The analysis of the precipitation variability was carried out on the basis of the precipitation data from 19 meteorological stations (MS) belonging to the National Meteorological Administration (NMA). These stations, with altitudes between 7 m a.s.l. and 280 m a.s.l., are considered representative for the study area (Fig. 1).The precipitation parameters used in the analysis are: the monthly average amounts and the annual amounts. The analysis was completed with the calculation of the standardized anomaly for the annual precipitation [8]. The formula used was: $x_{anomaly} = \frac{x-\mu}{\sigma}$, where$x_{anomaly}$is the standard anomaly; x isthe annual value; μ is the annual average value for the period 1991 – 2020 and $\sigma$is the standard deviation for the period 1991 – 2020.In order to capture the influence of the monthly and annual precipitation on the winter wheat yields, the average production data per hectare (ha) from the National Institute of Statistics (NIS) were analyzed for the period 1991 – 2020. The space-time analysis of precipitation was carried out using the statistical methods and GIS techniques.

RESULTS AND DISCUSSIONS

The water resources offered by Romania's climate are favorable in general, from the point of view of the values of the annual precipitation amounts, throughout the growing season of the winter wheat and in most of the country [13].For large productions, the water requirements, depending on the climate and duration of vegetation, are between 450 and 650 mm [9]. In Romania, according to the latest experimental research, the amount of approximately 600 mm of precipitation is considered optimal for the entire vegetation period [15]. The precipitation requirements of the winter wheat, over the entire growing season are moderate, but must be balanced as a monthly distribution. The minimum amount of precipitation required is 225 mm [114]. The annual average amount of precipitation, at the level of the entire study area, for the analyzed period is 567.4 mm, being very close to the optimal precipitation requirement for the entire vegetation period. The precipitation regime is characterized by a large space and time variability of the monthly precipitation amounts and also of the annual precipitation amounts. The precipitation may act, in some areas, both monthly and annually, as a risk factor and may become a limiting factor.

As a rule, for the analyzed period, in the annual regime of the monthly precipitation, the lowest monthly average amount of precipitation has been recorded in February, while the highest one has been recorded in June (Fig. 2).

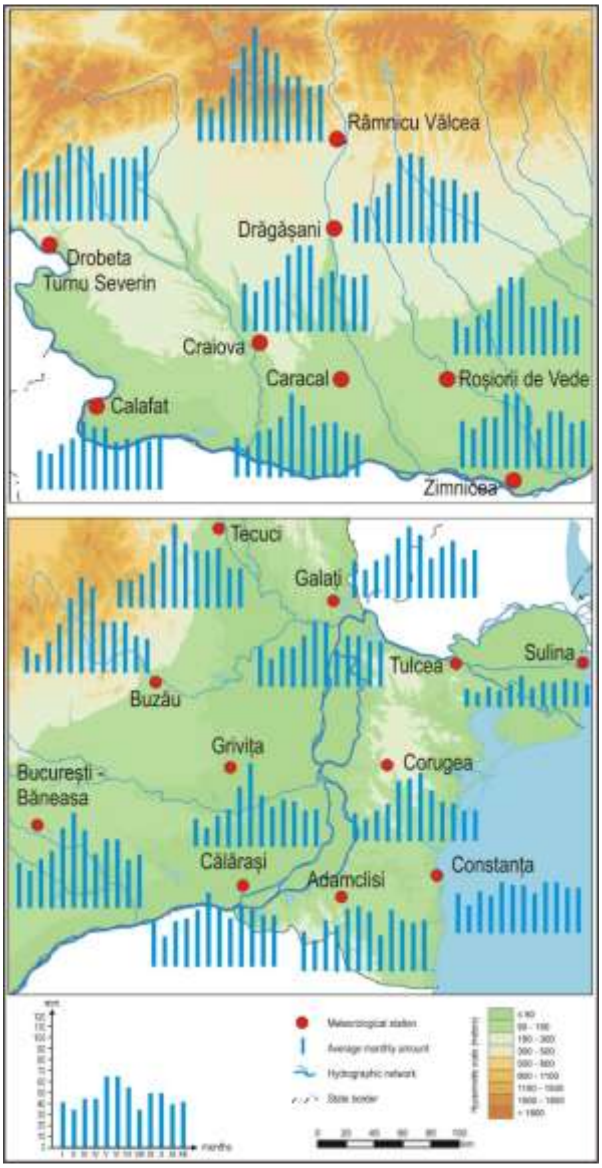

Fig. 2.The annual regime of the monthly average precipitation amounts (mm) at the meteorological stations analyzed for the period 1991 – 2020.
Source: own processing from GIS open sources.

The critical period with respect to precipitation of winter wheat is the interval May – June. During the vegetation months, the optimal precipitation requirement is rendered in Table 1[15]. The analysis of the distribution in space of the monthly precipitation amounts highlights the pluviometric potential of the analyzed region.

Table 1. The reference thresholds for the optimal precipitation requirement (mm) of the winter wheat. Note: light blue – critical period.

Culture	Month	Precipitation (mm)
winter wheat	IX	40.0
	X	60.0
	XI – III	200.0
	IV	50.0
	V	80.0
	VI	80.0
	VII	50.0
	VIII	40.0
	IX – VIII	600.0

Source: [15].

In relation to the reference thresholds of the optimal monthly precipitation values required for winter wheat, it is found the next, from Figure 2 and Table 1:

* The values of the lowest monthly average amount oscillate between 11.9 mm at Sulina MS and 42.7 mm at DrobetaTurnu (Dr. Tr.) Severin MS recorded in February.
* The values of the highest average monthly amount vary between 28.3 mm at Sulina MS and 100.7 mm at Râmnicu (Rm.) Vâlcea recorded in June. These precipitations are mostly in the form of showers and their quantitative distribution is uneven [1].
* From the point of view of the critical period for the winter wheat, for the analyzed period, the optimal precipitation requirement of 80 mm for the months of May and June was recorded in proportion 5.3% for May and 15.8% for June. At most meteorological stations, there is a precipitation deficit compared to the optimal requirement of 15 – 20 mm for May and 10 – 15 mm for June.
* The values of the annual precipitation amounts, for the period 1991 – 2020, vary between 240.5 mm at Sulina MS and 727.7 mm at Rm. Vâlcea MS.
* The Sulina meteorological station records the lowest precipitation values for both monthly and annual amounts. However, for the entire vegetation period of winter wheat, the annual precipitation amount is greater than the minimum required amount by 15.5 mm.

The increase of the continentalism degree determines, in the study area, a significant decrease in the precipitation amount from the West to the East[8]. Furthermore, the precipitation amount increases with 100 m by altitude in the temperate regions [4]. It has been noticed that only in the Eastern part of the study area, the degree of coverage of the optimal precipitation requirements satisfactory, while in the Eastern extremity of the Dobrogea Plateau, the degree of coverage of the optimal precipitation requirement is unsatisfactory (Fig. 2).

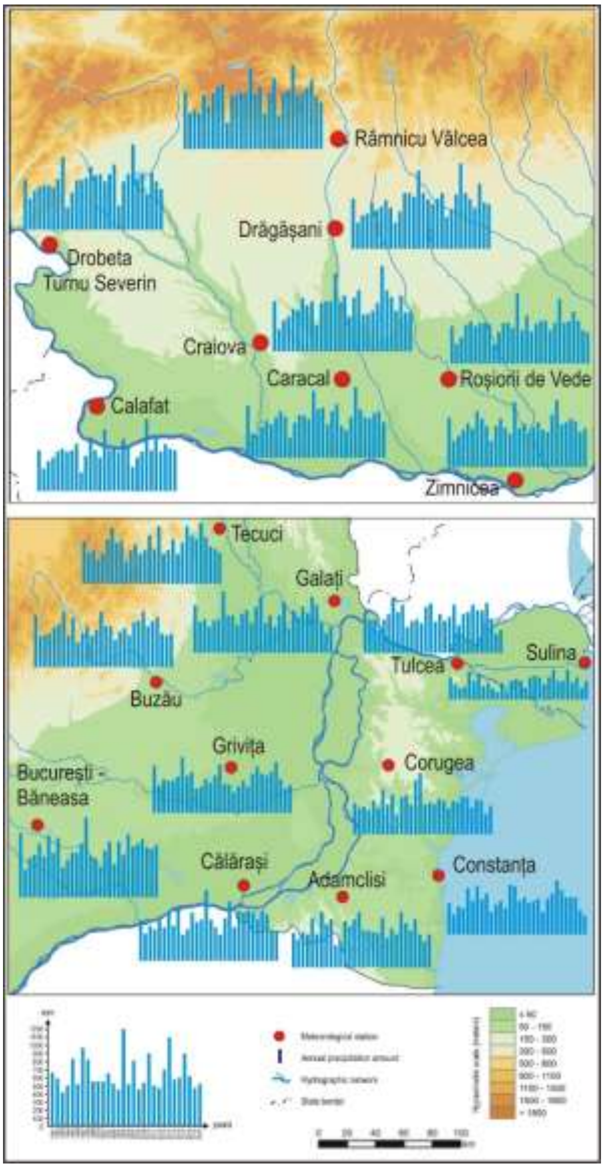

Fig. 3. The annual precipitation amount variation (mm) from one year to another, at the analyzed meteorological stations for the period 1991 – 2020.
Source: own processing from GIS open sources.

The annual precipitation amount varies from one year to another, resulting either from the internal processes of the climate system or from natural or anthropogenic variations of external forces [3].

Figure 3 shows that there is an annual fluctuation of the precipitation amounts in the study area for the period 1991 – 2020.

It has been noticed that the annual precipitation amount varies in the years with liquid precipitation excess or with a drought phenomenon. In the study area, it is stand out:

* Years with excess precipitation: 1997, 1999, 2004, 2005, 2007, 2010, 2014, 2016, 2017. Among them, the most representative are the years 2005 and 2014, which are predominant at most of the meteorological stations analyzed (Fig. 3). For example, at Rm. Vâlcea MS, both in 2005 and in 2014, the annual precipitation amounts over 1,000 mm were recorded. At Sulina MS, the highest annual precipitation amounts were recorded in 2016 (400.4 mm) and 2014 (390.4 mm).
* Dry years: 1992, 1993, 1994, 2000, 2003, 2008, 2011, 2019, 2020. The representative years for most of the meteorological stations analyzed are 2000, 1992 and 2008. In 2000, the annual precipitation amount was recorded at Rm. Vâlcea MS of 350.2 mm and at Sulina SM, in 2003, the amount of 109.5 mm was recorded (Fig. 3).

As a result, based on Figure 3, we can conclude that at any of the meteorological stations analyzed, the annual precipitation fluctuations are recorded, which are obviously reflected in the level of yields obtained.

This annual fluctuation in the precipitation amounts is also evident from the calculation of the standardized anomaly for the annual precipitation (Fig. 4). It is found that positive anomalies alternate with negative ones and that their frequency differs from one station to another. In the study area, at most of the meteorological stations analyzed, a higher frequency of negative anomalies is found for the first decade of the analyzed period, 1991 – 2010.

For the last decade of the analyzed period, 2011 – 2020, no particular pattern can be observed, but it is need for point-by-point analysis of each station. This aspect once again reflects the need to evaluate the degree of agroclimatic favorability of agricultural areas in order to adopt the best preventive measures, reducing and combating effects on crops and yields.

Obtaining minimum yields of the winter wheat corresponding to the surface unit is not ensured by the annual precipitation amount, but by the distribution of the monthly amounts of precipitation during the vegetation period of the plants [2].

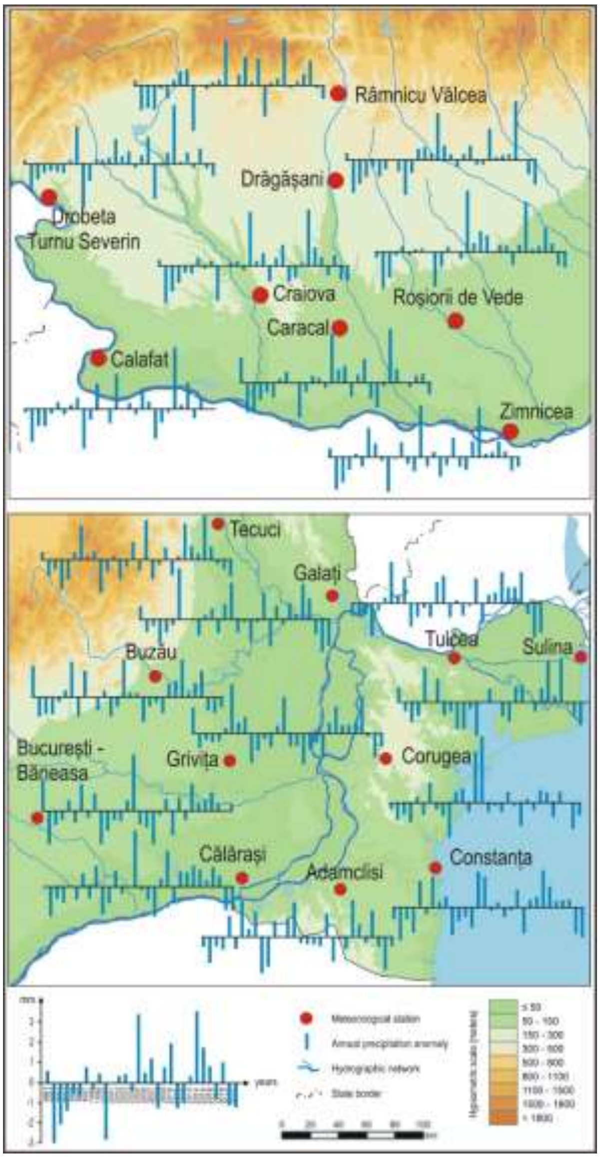

Fig. 4. The annual precipitation anomaly (mm) at the analyzed meteorological stations for the period 1991 – 2020.
Source: own processing from GIS open sources.

The variability of the precipitation influences the productivity of the winter wheat, one of Romania's strategically important crops, which presents significant annual yield fluctuations. These yields are much more affected in years when extreme climate events occur, such as drought and periods of excess precipitation. Table 2 shows the annual yields at the level of the entire study area for the period 1991 – 2020. The yields varied between 848 kg/ha in 2003, one of the dry years and 4,875.3 kg/ha in 2017, considered a year with excess precipitation (Table 2).

Table 2. The average production per hectare (kg/ha) of the winter wheat in the study area (1991 – 2020). Note: light yellow – the lowest average production per hectare; dark yellow – the highest average production per hectare.

Culture	Year	Average of production (kg/ha)	Year	Average of production (kg/ha)
winter wheat	Decade 1991 – 2000			
	1991	2,524.3	1996	1,386.5
	1992	2,517.0	1997	3,018.5
	1993	2,284.0	1998	2,535.5
	1994	2,180.3	1999	2,960.3
	1995	2,976.5	2000	2,343.0
	Decade 2001 – 2010			
	2001	2,994.5	2006	2,824.0
	2002	1,514.0	2007	1,115.8
	2003	848.0	2008	3,381.8
	2004	3,343.5	2009	2,324.3
	2005	2,890.8	2010	2,708.0
	Decade 2011– 2020			
	2011	3,641.0	2016	3,946.0
	2012	2,566.0	2017	4,875.3
	2013	3,500.3	2018	4,746.3
	2014	3,616.0	2019	4,758.0
	2015	3,824.5	2020	2,793.8

Source: processed data from NIS, 2023 [12].

Because the agricultural production depends on precipitation amounts, the need for irrigation follows. A good commercial yield, under the irrigation norm of the winter wheat is 6 – 9 tons/ha [15]. In any year of the analyzed period, there was not an average production per hectare higher than 5 tons in the non-irrigated winter wheat crop.

CONCLUSIONS

The use of the agroclimatic information in agricultural management would diminish or avoid the negative impact of the natural variability of the climate factor, but currently intensified due to the current global warming. The pluviometric resources of an area influence the level of agricultural yields year by year, depending on the duration and intensity of the disturbing factor, but especially on the mode of action alone or associated with the thermic and light resource, to which is added the bioclimatic requirement of the plant during the period of vegetation.

The aim of this study was to analyze the singular mode of action of the precipitation on the winter wheat crop.

The main source of water for the development and growth of any agricultural crop is the precipitation. The quantitative variability andthe space-time distribution for the period 1991 – 2020 are reflected in the year-to-year fluctuation of the winter wheat yields. It was found that in the dry years, with annual precipitation amounts far below the optimal value of 600 mm, the yields are low and in years when the annual amounts were close to or greater than the optimal amount of precipitation, the yields were high. It was also found that there are years in which this optimal precipitation requirement is ensured for the entire vegetation period, but the recorded yields are lower as a result of the distribution of monthly precipitation amounts that do not ensure the optimal monthly precipitation requirements.

The analysis of the variability of the main climatic factors allows, for each agricultural area, the selection of crop plants and the establishment of the necessary measures for the development of the agricultural production process from the point of view of the cost-benefit ratio.

REFERENCES

[1]AdministrațiaNațională de Meteorologie (National Meteorological Administration–NMA), 2008, Romania's Climate (ClimaRomâniei), Academia RomânăPublishing House, București.

[2]Bîlteanu, Ghe., 2001, Fitotehnica, Vol. 1, CeresPublishing House, București.

[3]Bojariu, R., Chitu, Z., Dascălu, S.I., Gothard, M., Velea, L.F., Burcea, R., Dumitrescu, A., Burcea, S., Apostol, L., Amihaesei, V., Marin, L., Crăciunescu, V.S., Irimescu, A., Mătreață, M., Niță, A., Bîrsan, M.V., 2021,Climate change – from physical foundations to risks and adaptation (Schimbările climatice – de la bazele fizice la riscuri și adaptare),PrintechPublishing House, București.

[4]Ciulache, S., Ionac, N., 2007, Essential in meteorology and climatology (Esențial în meteorologie și climatologie),University Publishing House,București.

[5]Constantin (Oprea), D.M., Vătămanu V.V., Cofas E., Zaharia I., 2016, Aspects concerning the demands of the winter wheat culture in comparison with the climatic conditions in the Caracal Plain. Case study: the agricultural year 2006 – 2007. Scientific Papers Series „Management, Economic Engineering in Agriculture and Rural Development”, Vol. 16(2):103-109.

[6]Constantin (Oprea), D.M., Mincu (Stan) F.I., Tișcovschi A.A., Grigore E., Vătămanu V.V., Ilea R.G., 2022, Determination of water consumption for winter wheat in Southern Romania. Case study: Caracal Plain, agricultural year 2017 – 2018. Actes du 35ème Colloque de l'Association Internationale de Climatologie, 73-77, http://www.meteo.fr/cic/meetings/2022/aic/resumes/agrometeo_constantin.pdf, Accessed on February 5, 2023.

[7]Constantin (Oprea), D. M., Marinică, I., Marinică, F.A., Grigore, E., Tatu, F., Dîrloman, G., Ardelian, D.V., 2022, The climate variability of the year 2019 and the impact on the maize production in the Southern-Western Development Region of Oltenia, Romania. Scientific Papers Series „Management, Economic Engineering in Agriculture and Rural Development”, Vol. 22(2):225-230.

[8]Constantin (Oprea), D. M.,Tișcovschi, A.A.,Irimescu, A., Grigore, E., Ilea, R.G., Dîrloman, G., 2022, Observed changes in the temperature and precipitation regime along the lower Danube River, In: Negm, A., Zaharia, L., Ioana-Toroimac, G. (eds) The Lower Danube River. Earth and Environmental Sciences Library. Springer, Cham, pp. 273-297. https://doi.org/10.1007/978-3-031-03865-5_9. , Accessed on February 5, 2023.

[9]Food and Agriculture Organization of the United Nations (FAO), Wheat. https://www.fao.org/land-water/databases-and-software/crop-information/wheat/en/, Accessed on March 10th 2023.

[10]Ion, V., 2010,Phytotechnics (Fitotehnie). https://www.horticultura-bucuresti.ro/images/pdf/Fitotehnie.pdf, Accessed on March 10th 2023.

[11]Mateescu, E., Tanislav, N., Vătămanu, V.V., 2004,Impact of drought conditions in the Caracal Plain on wheat and maize crops (Impactul condițiilor de secetă din Câmpia Caracalului asupra culturilor de grâu și porumb),Sitech Publishing House, Craiova.

[12]National Institute of Statistics, 2023, www.insse.ro, Accessed on Fabruary 10, 2023.

[13]Povară, R., 2000,The meteorological risk in agriculture. Winter wheat. (Riscul meteorologic în agricultură. Grâul de toamnă.),Economic PublishingHouse, București.

[14]Roman, Ghe.V., Epure, L.I., 2013, Phytotechnics. Cerealsandgrainlegumes (Fitotehnie. Cereale și leguminoase pentru boabe). Departamentul de Studii pentru Învățământul cu Frecvență Redusă. Specializarea: Agricultură, USAMVB, București.

[15]Sandu, I., Mateescu, E.,Vătămanu, V.V., 2010, Climate change in Romania andtheireffects on agriculture (Schimbări climatice în România și efectele asupra agriculturii). Sitech Publishing House, Craiova.