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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

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Abstract

The crops are vulnerable to variations in the annual climate, therefore, reducing losses and increasing the agricultural production are necessary, both economically and socially. The purpose of this paper is to analyze the thermic and hydric resources and to indentify the agro-climatic parameters and critical thresholds on the intervals of period September 2006 – August 2007, with direct consequences for the winter wheat crops in the Caracal Plain. In the first decade of the 21st century, the crop year 2006–2007, was characterized, in general, by a higher air temperature than normal, with soil humidity deficit, which determined the depreciation of the vegetation state of the winter wheat crop and consequently, a low production per hectare. By knowing the climatic conditions, for a period of time, it provides the ability of implementing effective measures in order to prevent and combat effects on agricultural production.

Key words**:** *thermic resources, hydric resources, winter wheat, the Caracal Plain.*

INTRODUCTION

The winter wheat is the most important culture in Romania, both by the cultivated area and its economic and social value. Due to its ecological plasticity, the winter wheat can adapt to various climatic conditions [2]. The rational use of the climatic conditions in agriculture requires to know how the cultivated plants react to the permanent changes in their evolution, as a part of the biotope [1].
The main climatic factors limiting the winter wheat, as a cultivated plant, are: the temperature, precipitations and the light [11]. In Romania, the winter wheat proved to be more productive than the spring wheat, that is why the former occupies 99 % of the total area sown with this plant, while the spring wheat is cultivated on small areas in the Transylvania Depression [3]. The vegetation season of the winter wheat depends on the climatic and soil conditions and on the cultivated variety, therefore this is, generally, between 230 and 250 days. In the southern part of Romania, where the Caracal Plain is situated, the winter wheat is sown after September 25th and harvested in early July. [12].
The variability of the agro-meteorological parameters in each crop year, provides favorable or restrictive conditions for each phenological phase and productivity of the cultivated wheat. [5].
The characterization of a crop year consists of an agro-meteorological analyzis of the period

from September to August, which corresponds to the vegetation season for the field crops. In this paper, there will be analyzed the climate of the crop year: September 1st, 2006 – August 31st, 2007, in terms of the thermic and hydric resources from the air and from the soil surface, for the winter wheat in the Caracal Plain area.

Arguments for the choice of the agricultural year 2006 – 2007 as year of study is not based on the consideration available data, but on highlighting the climatological characteristics of this year, in relation to series of records of the first 15 years of this century, as an essential factor in analysis of the influence of climatic factors on crop yields and, consequently, in identifying the type of agricultural management suitable for such specific situations – all this in a context where it is known that all crops are exposed in each agricultural year at risk occurrence of extreme weather events – drought, heat, floods etc. The climatic analysis will be done for the crop year 2006 – 2007, because:

- in the first decade of the XXI century, in the five years to agricultural drought (2000 – 2001; 2001 – 2002; 2002 – 2003; 2008 – 2009) the crop year 2006 – 2007 was an extremely dry year, like the crop year 1945 – 1946;
- its summer is comparable to that of the year 1946, but with a higher number of hot days ($T_{max} \geq 35.0$ °C) and with a excessive drought which, by its duration and intensity of water deficit, was above the crop year 1945 – 1946, which was considered the driest year in the last five decades of the 20th century [12];
- the absolute maximum monthly teperature of air in Romania for July was 44.3 °C on July 24th, 2007 at Calafat – Danube Valley in Oltenia Plain (close to absolute maximum temperature in Romania, 44.5 °C, recorded at August 10th, 1951 in the Ion Sion locality, near Braila town);
- for the period 1961 – 2013, the year 2007 is the warmest year in Romania, registering an average annual temperature in the country of 10.6 °C, with a positive drift of 1.8 °C compared to the average annual multi followed in descending order the years 1994, 2009, 2000, 2008, 2002 and 2013;
- in the first nine months of agricultural year 2006 – 2007 were recorded particularly low values of rainfall for the entire agricultural area of the country, highlighting such an extremely dry year for almost all crops;
- in the second decade of the XXI century, so far, the dry crop year is considered the year 2011 – 2012, but without touching the seriousness of the agricultural year 2006 – 2007.

The Caracal Plain is located in the southern Romania, being a part of the Romanian Plain composed of the terraces of the Olt and the Danube river [7]; [8]. It is located in the west of the Olt Valley, with altitudes between 180 – 190 m in the north and 45 – 50 m in the south, and a homogeneous landscape (Figure 1B) [4].

Fig. 1. The geographical location of the Caracal meteorological station (A) and of the Caracal Plain (B) in Romania
Source: Own processing from www.google.ro

MATERIALS AND METHODS

The climatic analyzis of the crop year 2006 – 2007 and the impact on the vegetation season and production of the winter wheat obtained for the Caracal Plain have used: the meteorological data from the Caracal meteorological station (situated at 112 m altitude) (Figure 1A), the agro-meteorological information elaborated by the National Administration of Meteorology [15], the production data from the Olt Directorate for Agriculture [14], statistic methods, graphics and maps.

The climatic analysis is completed by

calculating the Lang precipitation index and the hidro-thermic index. At these climatic indices, there are added indices which set precipitation values for certain periods of which the annual amount is characteristic [6].

RESULTS AND DISCUSSIONS

Although the winter wheat can adapt to different climates in order to achieve profitable crops, the climatic factors such as: air temperature, soil surface temperature, precipitation, air humidity etc. have a great importance.

The air temperature affects the physiological processes of the winter wheat, thus, for each stage of development, there are upper and lower temperature limits, besides which the thermic stress also occurs, and also temperature limits at which the vital functions cease.

For the crop year 2006 – 2007, in the Caracal Plain, the annual average temperature was 13.8 °C, which is higher than normal. In the Oltenia region, which includes the studied area, farming for the period 1961 – 1990, the annual average air temperature was 10.6 °C, and for the period 2001 – 2008 of 11.4 °C [12], the positive deviations are 3.2 °C and 2.4 °C, respectively.

Analyzing the annual air temperature regime at the Caracal meteorological station, there was recorded an air temperature of 19.5 °C in May, and 23.8 °C in June (Figure 2).

The interval from May to June is the critical period for the winter wheat (earing - flowering - formation and grain filling), the thermic optimum being between 16 °C – 20 °C for May and 16 °C – 22 °C for June [1].

The values recorded are at the limit and beyond, but do not exceed the maximum temperature, between 30 °C and 35 °C. July was very hot, with values of 27.2 °C, forcing the physiological processes, and reducing the vegetation period.

The winter months register positive values between 2.2 °C in December and 4.2 °C in February (Figure 2). At 0 °C and below, the biological activity is stopped and the winter wheat falls during winter. The pronounced winter thermic instability, with relative warm periods alternating with cold and frosty winter periods, produces injuries to the winter wheat crop.

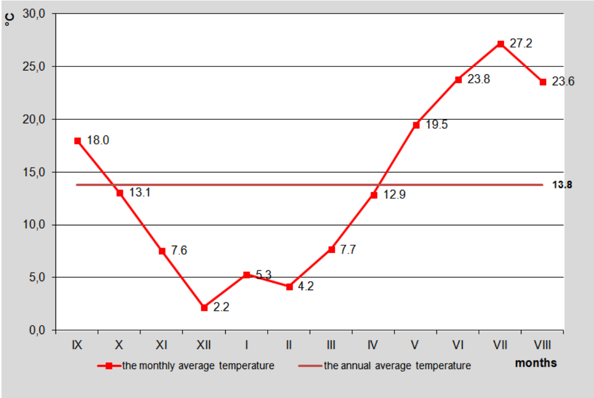

Fig. 2. The annual air temperature regime (°C) at the Caracal meteorological station, in the agricultural year 2006 – 2007
Source: Processed data after ANM

In the periods of maximum demands in comparison with the specific climatic conditions of the winter wheat vegetation processes, the quality and level of production may be affected because of the heat phenomenon.

In the crop year 2006 – 2007, at Caracal, there has been recorded a total of 78.0 tropical days, representing 22 % of the total year. The monthly maximum was in July, of 28.0 days, meaning 90.3 % of the month, the maximum temperature being ≥ 30 ° C (Tabel 1).

In the same month – July, there has been recorded the highest maximum temperature, of 41.9 °C, while the monthly average of the daily maximum was 35.2 °C (Tabel 1).

During May 1st – July 31st, 2007, the heat appeared and accelerated, the maximum intensity being between July 15th and July 24th, 2007.

This phenomenon represents the quantification of the heat (thermic) stress in the critical period of the culture, which through intensity ($\Sigma t_{max} \geq 32$ °C/units of heat) and lasting (number of days with heat). In this monthly interval, at Caracal, there were recorder the values: 135.6 units with heat; a total of 37 days with heat (40.2 % of the monthly interval) and 3 intervals with 9 consecutive heat days from June 19th to 27th; 5 days from July 1st to July 5th and 17 days between July 15th to July 31st [12].

Tabel 1. The distribution of the agro-climatic parameters, at the Caracal meteorological station, in the agricultural year 2006 – 2007

Month	Minim tempe-rature (°C)	Maximum tempe-rature (°C)	No. of tropical days ($t_{max} \geq 30$ °C)	No.of days with frost ($t_{min} \leq 0$ °C)
IX	9.3	30.7	3.0	0.0
X	-1.0	30.6	2.0	1.0
XI	-4.7	20.7	0.0	6.0
XII	-7.5	15.6	0.0	16.0
I	-3.4	18.2	0.0	11.0
II	-8.5	18.2	0.0	15.0
III	-1.3	20.9	0.0	1.0
IV	-1.0	27.4	0.0	1.0
V	2.9	32.0	6.0	0.0
VI	12.2	39.7	18.0	0.0
VII	11.9	41.9	28.0	0.0
VIII	13.7	37.2	21.0	0.0

Source: Processed data after ANM

The high air temperature values during the elongation of the straw emphasize its growth, causing a slight drop resistance, while during the filling of the grain, these temperatures impede a good pollination and fertilization, increasing the phenomenon of fading wheat.

In the crop year 2006 – 2007, the lowest minimum temperature was -8.5 °C in February, when it was also registered the lowest monthly average of the minimum temperatures, of -0.8 °C (Tabel no. 1). The total number of days with frost, when the minimum temperature is ≤ 0 °C, was 51 days, meaning 13.9 % of the year. The highest number of days per month was 16 days in December, meaning 51.6 % of the month. Days with frost were recorded monthly, between November 2006 and April 2007, but for November, March and April, there was registered 1 day/month. (Tabel no. 1). During winter, the wheat can withstand temperatures of -12 °C to -15 °C, for 2 – 3 days, if the hardening phase went well, and by its end, the frost resistance gradually decreases.

The surface soil temperature mainly affects the winter wheat germination, emergence and twinning. If the soil temperature values in these phenological stages are higher, the faster the seeds are growing, also depending on an optimal humidity. Also, the soil temperature determines the absorbtion of nutrients and the root system development etc. [10].

At the Cacaral meteorological station, the annual average temperature, at soil surface, for the crop year 2006 – 2007 was of 15.4 °C. In the annual regime, all the months register positive values, the lowest value being in December: 2.7 °C, while the highest temperature value was in July, 32.9 °C (Figure 3).

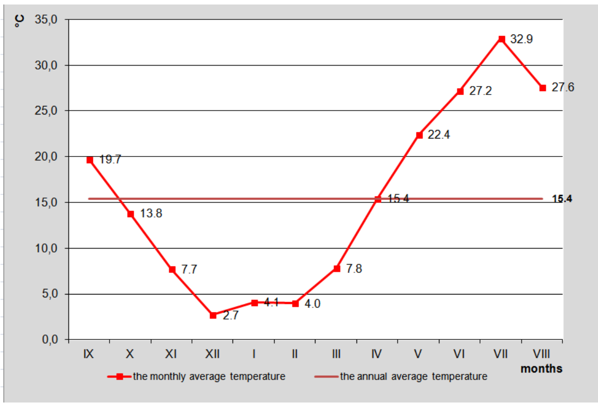

Fig. 3. The annual regime of the surface soil temperature (°C) at the Caracal meteorological station, in the agricultural year 2006 – 2007
Source: Processed data after ANM

In September and October, there were recorded values of 19.7 °C and 13.8 °C, falling to the thermic optimum of 10 °C – 20 °C for the phenological phases of sowing, germination and emergence. In November, when it begins the twinning, the optimum heat is 8 °C – 12 °C, while the recorded value is 7.7 °C. The minimum temperatures for the twinning phase are between 4 °C – 6 °C. Changes in the soil temperature determine the humidity regime and, therefore, modify the conditions of wheat.

The precipitations are the natural source of water supply for the soil. The ”silent” rainfalls are the most useful to plants, because they are well retained by the soil and its fertility through nitrogen can increase, this nitrogen being brought as nitrates and ammonia salts from the atmosphere [13].

At Caracal, for the crop year 2006 – 2007, there have been recorded annual precipitations of 460.4 mm, these being in a negative deviation, comparing to, both the annual quantity, for the period 1961 – 1990, in the agricultural region of Oltenia of 189.9 mm, and also, for the period 2001 – 2008, with 249.1 mm. In Romania, in the crop year 2006 – 2007, there was recorded an amount of 479.2 mm [12]. As a result, the crop year 2006 – 2007, in terms of the annual precipitations, registered a deficit, comparing to the demands for the optimal growth and development of the winter wheat crop (600 mm), being a moderate dry year (450 – 600 mm).

In the annual regime, the monthly precipitations recorded between 0.0 mm in April and 129.0 mm, in August (Figure 4).

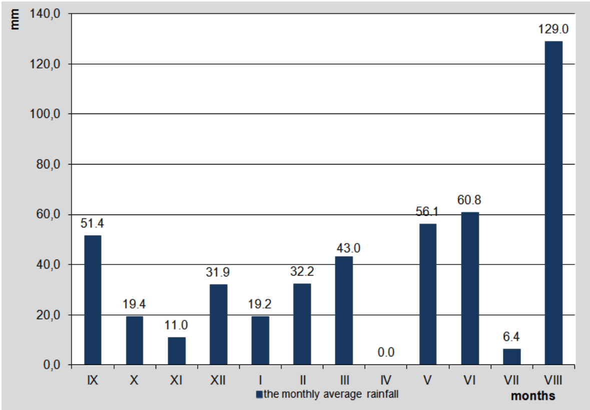

Fig. 4. The annual precipitation regime (mm) at the Caracal meteorological station, in the agricultural year 2006 – 2007

Source: Processed data after ANM

With reference to the monthly amounts of precipitations, there has not been reached the optimum level of precipitations for November (60.0 mm), April (50.0 mm), June (80.0 mm) and July (50.0 mm) [12], the monthly values recorded at the Caracal meteorological station, being less below the optimal limits mentioned before (Figure 4). The greatest demand of water, for the winter wheat crop is during earing period and during early graining of the wheat, meaning from April to June. The precipitations for this monthly interval (ΣP_{IV-VI}) registered a value of 116.9 mm, being assigned as a mildly dry regime. April was considered excessively dry.

During the period of water accumulation in soil (ΣP_{XI-III}), the precipitation regime corresponded to a dry one, being of 137.3 mm, thus maintaining the soil water deficit for the winter wheat growing, for the profile 0 – 100 cm. The optimum of precipitation for this period is 200 mm.

During the active vegetation season of the winter wheat crop (ΣP_{IV-X}), the precipitation regime was dry (251 – 350 mm) being 323.1 mm for the Caracal Plain area.

For the crop year 2006 – 2007, at the Caracal meteorological station, there has been recorded a total of 63 days with precipitation ≥ 1.0 mm, representing 17.2 % of the year. The monthly number of days with precipitations ≥ 1.0 mm varied from 0 days in April to 9 days in May.

The relative air humidity prevents transpiration, pollination, flowering and fructification at higher values, and at low levels, the transpiration increases and also the water consumption [5]. For the crop year 2006 – 2007, at Caracal, the annual average is 64.8 %. In May, June and July, when there are the phenological stages of flowering and maturity, the relative air humidity values are 58 %, 55 % and 35 % respectively. The optimal values of the relative air humidity to conduct the vegetative activity within this monthly interval, are 60 – 90 %. Values ≤ 50% of the relative air humidity show a large deficit of moisture in the air. For the same month, the minimum relative humidity was 14 %, 17 % and 11 % respectively (Table 2).

Tabel 2. The average and monthly minimum relative air humidity (%), at the Caracal meteorological station, in the agricultural year 2006 – 2007

Month	Relative humidity	Minimum humidity
IX	68	26
X	76	30
XI	74	30
XII	87	53
I	72	27
II	73	29
III	68	29
IV	48	18
V	58	14
VI	55	17
VII	35	11
VIII	63	19
an	64.8	25.3

Source: Processed data after ANM

In order to determine the humidity content of the active vegetation season for the winter wheat, in the Caracal Plain, in the crop year 2006 – 2007, there were calculated the Lang precipitation index and the hydro-thermic index.

The Lang precipitation index or the rainfall factor (mm/°C) indicates the atmospheric humidity degree. This index is calculated using the formula: $I_{Lang} = P/T$, where P respresents the annual precipitation quantity, while T is the annual average temperature [9]. At Caracal station, for the period of study, the Lang precipitation index was 33.4. Values below 70 indicate a mildly dry regime.

The hydro-thermic index (units) is calculated after the formula: $I_h = (P \cdot T) / 1000$, where P is the annual precipitation quantity, while T is the annual average temperature [9]. At the Caracal meteorological station, the value of this index is 6.3, indicating a moderate drought, same as the Lang precipitation index.

CONCLUSIONS

The synergy of the agro-climatic parameters is reflected in the reactions of the winter wheat crop, during the successive vegetation periods.

Purpose of an agro-meteorological analysis for an agricultural year is to evaluate vulnerabilities and adaptation measures of agro-ecosystems to climate changes.

In the agro-meteorological terminology, agricultural year 2006 – 2007 it was an extremely dry year and belongs to a series of dry years of the XXI century, so the climatological analysis establishes the importance of the winter wheat variety for the design of new genotypes with raised resistance to extreme temperatures and deficiency of rainfall.

Also, on the basis of such analyzes, it highlights the certainty of change sowing the date for the winter wheat, from September 25th to October 20th, at present, to October 20th to November 10th, during future of the climate in south and southeast of the country.

Analyzing the thermic and hydric resources for the Caracal Plain, from September 1st, 2006 to August 31st, 2007, it has been recorded an air temperature regime more pronounced than normally in winter, spring and summer, which determines a phenology advance of 3 – 4 weeks in the evolution of the winter wheat crop [12].

Along with the air and soil surface temperature regime, the water stress intensified, being caused by the soil drought. All these affected the winter wheat crop which was in the period of flowering, formation and grain filling, milk-wax maturity, causing the intensification of ripening and even compromising by over 50 % the crops.

Taking into account the agro-climatic favourability index of the agricultural land in relation with the bio-climatic demands of the winter wheat, the Caracal Plain belongs to the 1st area of favourability, subzone no. 3 [11]. Despite it belongs to the most favourable area, the Caracal Plain is situated in the area with the most frequent droughts, that is why irrigations are needed during the periods with maximum demands of water.

The thermic and hydric oscillations cause large variations for harvests from year to year. The crop year 2006 – 2007 is a referrence year for the first decade of 21st century, in terms of drought in Romania, being related to the compromised crops on large arable land.

The direct consequence of the climate, in the agricultural year 2006 – 2007, is the production of winter wheat obtained in the Caracal Plain area. The winter wheat productions are presented for several administrative units of the studied area in the Table 3.

Tabel 3. The cultivated area and the winter wheat production, in the Caracal Plain, for the agricultural year 2006 – 2007

Locality	Surface (ha)	Production (tone)
Caracal	1,415	1,157
Corabia	3,995	2,596
Babiciu	1,440	764
Brastavățu	4,025	2,688
Cilieni	1,874	1,180
Deveselu	1,305	1,089
Dobrosloveni	1,763	2,478
Fălcoiu	850	417
Izbiceni	1,228	388
Rusănești	2,154	1,954
Stoenești	901	564
Studina	1,521	915
Tia Mare	1,635	1,387
Vișina	1,514	1,248
Vlădila	1,194	964

Source: Processed data after DADR Olt

In conclusion, there was obtained an average of 1.4 tons of winter wheat per hectare, representing a low production in comparison with the bio-climatic potential of the area.

REFERENCES

[1]Berbecel, et al., 1970, Agrometeorologie, Editura Ceres, Bucureşti.
[2]Bîlteanu, G., 1998, Fitotehnie, vol 1, Editura Ceres, Bucureşti.
[3]Bîlteanu, G., 2003, Fitotehnie, vol 1, Cereale şi leguminoase pentru boabe, Editura Ceres, Bucureşti.

[4]Constantin (Oprea) Dana Maria, Vătămanu V.V., Considerations upon the dryness and drought phenomena in the Caracal Plain, Romania, Scientific Papers Series „Management, Economic Engineering in Agriculture and Rural Development", Vol. 15 (1): 119–122

[5]Constantin (Oprea) Dana Maria, Vătămanu V.V., Considerations upon the climatic characteristics of the agricultural year 2011–2012 in the Olt County, Scientific Papers Series „Management, Economic Engineering in Agriculture and Rural Development", Vol. 15 (3): 109–112.

[6]Gageu, O., 2002, Elemente de climatologie practică, Editura Universităţii din Oradea.

[7]Iagăru, G., Vătămanu, V.V., Bălănescu, D., 2001, Clima şi solurile judeţului Olt, Editura Sitech, Craiova.

[8]Institutul de Geografie, 2005, Geografia României, vol V, Editura Academiei Române, Bucureşti.

[9]Ionac, N., Grigore, E., Constantin (Oprea) D.M., 2015, Évaluation des phénomènes de dessèchement et de sécheresse dans la zone continentale du Plateau de la Dobroudja du Sud. Actes du 28ème Colloque de l'Association Internationale de Climatologie, 269 – 274.

[10]Lungu, M., 2013, Agrometeorologie, Editura Universitară, Bucureşti.

[11]Povară Rodica, 2000, Riscul meteorologic în agricultură. Grâul de toamnă, Editura Economică, Bucureşti.

[12]Sandu, I., Mateescu Elena, Vătămanu, V.V., 2010, Schimbările climatice în România şi efectele asupra agriculturii, Editura Sitech, Craiova.

[13]Săndoiu Ileana, 2001, Agrometeorologie, Editura Ceres, Bucureşti.

[14] http://www.dadr-olt.ro/dadr/directia-agricola

[15] http://www.meteoromania.ro/anm