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THERMAL AND WATER RISK AGRO-METEOROLOGICAL PARAMETERS AND THEIR IMPACT ON WINTER WHEAT CROPS (*Triticum aestivum* L.) IN MUNTENIA REGION

Oana-Alexandra OPREA[1,2], Elena MATEESCU[1]

[1]National Meteorological Administration, 97 Bucureşti-Ploieşti, District 1, 013686, Bucharest, Romania
[2]University of Agronomic Sciences and Veterinary Medicine of Bucharest, 59 Mărăşti Blvd, District 1, Bucharest, Romania

Corresponding author email: oana.alexandra.oprea@gmail.com

Abstract

Thermal and water risk agro-meteorological parameters can have a direct and sometimes irreversible impact on crops, causing a significant reduction in agriculture production when it manifests severely, especially in certain critical ranges corresponding to the maximum winter wheat temperature and water discharge of the in Muntenia region.
Extreme meteorological phenomena, which can cause significant crop damages by their action, intensity and increased annual frequency, should be very well known and analyzed in order to take the adequate prevention and mitigation actions.
The lack of the rainfall over a long period causes visible negative effects on various components of the environment, but most important on the agricultural elements.
Due to the high thermal potential and to the optimal rainfall in southern Romania, Muntenia region presents the most favorable conditions for winter wheat crop.

Key words: *agro-meteorological indices, thermal and water risk, winter wheat.*

INTRODUCTION

The analysis of the thermal and water risk indices consist in agro-meteorological conditions characterization under crop's specific reference limits, closely related to the plants physiological demands, so that their positive or negative changes compared to the optimal thresholds are reflected in plant vegetation evolution and implicit in the harvest (Berbecel et al., 1980).
The potential of thermal resources of a region express natural conditions in terms of temperature values necessary for growth and development of plant species (Mateescu et al., 1999). The temperature scale values, there are certain limits to reference specific biological genotype (variety / hybrid), the top and bottom, in which the intensity of the physiological processes is apparent correlation with the values of this parameter. Variations in the positive / negative of the maximum optimal reflected thereby to the state of the growing crop and implicitly in crops, depending on the intensity and duration of thermal stress, genetic characteristics of genotypes grown expressed by the physiological requirements and resistance to extreme temperatures, the growth stage and development, technology, culture etc.
Temperature factor is one of the most important meteorological factors in the life of the plant. Biophysical and biochemical processes of the plant, as well as the water absorption of the gases and mineral salts, their movements within the plant, respiration, photosynthesis, etc. and the processes of growth and development depend on this factor. The rate of progress of the various stages of plant growth is influenced by the temperature, thereby determining the advance or delay of the phenological phases.
Rainfall is the main source of water for agricultural plant growth and the most significant elements of this parameter meteorological variability quantitative distribution and spatial-temporal distribution (Mateescu et al., 2003). The annual amount of

rainfall is indicative of specific varying amounts of each area of interest, and means the absence or abundance normality. The average yearly rainfall is a rainfall indicator climate reference for a agricultural zone, which may relate to extreme years, consider cases of agroclimatic risk. This value expresses the potential resources needed of rainfall determine the suitability of an agricultural area to a species or variety or hybrid.

The agricultural area of Muntenia region (Figure 1) shows the most favorable agrometeorological conditions, due to the high thermal potential compared to rainfall, the limiting factor with a negative impact on crop yields obtained from winter wheat and corn crops, is given by water from precipitation.

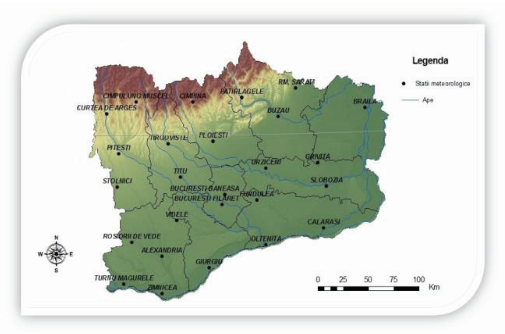


Figure 1. Muntenia Region

The climate of the Muntenia region is characterized by a temperate-continental regime, with submediteranee influences and aridity (sharper east of Arges and Bărăgan) between interfering movements east to the west (Posea, 2005). In the winter season, this area is exposed to blizzards and summer, to intense invasion or continental air masses. The air temperature remains negative, and during the day in 30-35 days from 110 days of frost. During the first half of warm season (March to August), the maximum temperatures above 25°C in 110-120 days, and 30°C in 40-60 days, absolute maximum values may exceed even 40°C. In this region signaled a high frequency's days, and the tropical nights, which highlights the character continental climate.

In terms of rainfall, the annual value in Muntenia is below 500 mm in the western region and below 400 mm in the east. In the summer season, are characteristic of prolonged periods of drought, up to 80-100 days with fine weather, strong insolation and wind (Bogdan et al., 1999).

MATERIALS AND METHODS

Specific agro-meteorological parameters, characterizing thermal and water risks impact on winter wheat crops in Muntenia region were analyzed.

The methodology was based on Muntenia's thermal and hydro resources analysis, with reference to the study of hydro-thermal specific indices, in direct correlation with the winter wheat plants water demands (Berbecel et al., 1970).

In order to evaluate the potential of the Muntenia available agro-climatic resources we have considered the data recorded at agro-meteorological weather stations that are representative for the agricultural region in the study area.

These meteorological data are continuous and cover the time period 1961-2015, analysis being carried out in terms of multi-annual averages relative to the 1981-2010 climate reference (***). The following parameters were studied:

Winter harshness, expressed by the phenomena intensity, namely cold intensity (sums of mean air temperatures below 0°C) recorded in the November to March period and frost intensity (sums of minimum air temperatures ≤15°C) in December-February interval.

Average production data of the early autumn and late spring frosts, respectively the dates when the air temperature fall below 0°C in autumn and winter seasons.

Spring index, expressed by sums of positive average temperatures and calculated for the 1st of February to the 10th April interval.

The intensity (sums of maximum temperatures ≥32°C) and duration (average number of days with maximum temperatures ≥32°C) of the heat phenomenon from June to August.

Precipitation amounts over specific intervals from the agriculture point of view, in direct correlation with the water winter wheat demands (September-October, November-March, April-October, May-June and September-August).

RESULTS AND DISCUSSIONS

Depending on the species (thermophilic, mesophilic) and phenological stages (germination, sprouting, plant emergence, budded, etc.), agricultural crops requirements on temperature are variable. To browse each phenological stage, the crop plants must achieve thermal thresholds (sums of temperatures) required for each specific genotype. Winter wheat crop has a special feature which is that it passes through the agriculture cold season (December-February), when the thermal variations specific to our country climate take place.
Heat index is of particular importance in the succession of growth and development phases of winter wheat crop. The agriculture plants vegetative processes rhythms differentiate depending on the demands of the cultivated species, the physiological processes intensity being in direct correlation with the heat factor evolution between genotype-specific thresholds.
In Figure 2 illustrates the evolution of the multi-annual temperature averages (1961-2015) recorded at representative weather stations from Muntenia agricultural region. It points out that at the majority of weather stations there is a linear upward trend, with positive deviations between 0.5 and 1.3°C and only isolated, at Campulung station, with negative deviation to the reference period 1981-2010.

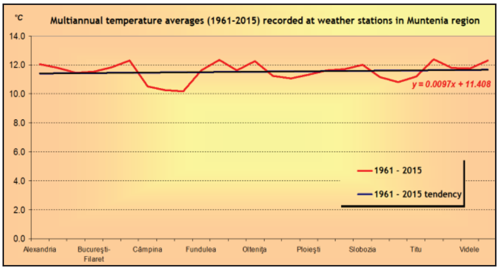


Figure 2. Multiannual temperature averages (1961-2015) recorded at weather stations in Muntenia region

Analysis of agro-meteorological indices specific to the crop year cold season (from November to March) outlines the degree of favorability with regard to the crops growing conditions, in terms of thermal resources (Mateescu et al., 1999).

Agro-meteorological parameter "winter harshness" characterizes the cold period by the average daily amount of negative air temperatures (Σtmed.≤0°C/cold units) recorded in the November to March period and by the amount of minimum air temperatures below -10 ... -15°C / frost units in December-February period in order to assess the winter crops conditions for autumn wheat. Thus, the analysis of "cold units" (Tmed≤0°C) accumulated in the period 1961 to 2015 (Figure 3a) compared to the range of 1981 to 2010 (Figure 3b) show the character of a normal winter phenomenon with an moderate intensity (201-240 ”cold units”) in most parts of the region. Local north, west and south of the territory, cold intensity was low (<200 "cold units").

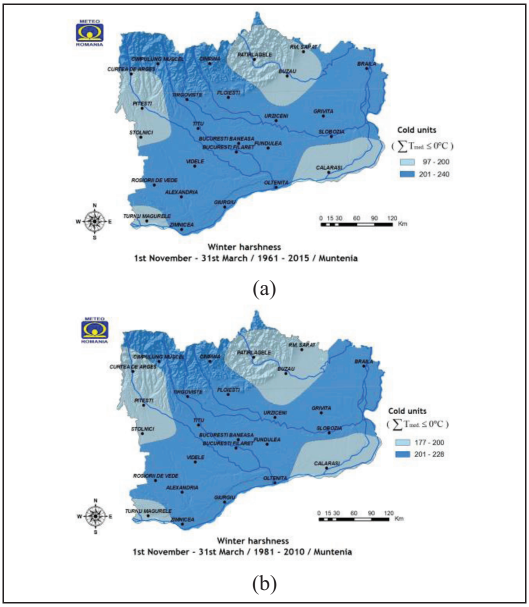


Figure 3. Cold units recorded during November-March period from 1961 to 2015 (a) compared to the period 1981-2010 (b) in Muntenia Region

Figure 4 presents the "frost units" spatial distribution, respectively the sum of the minimum negative air temperatures below the agricultural crops critical limits of resistance (Tmin.≤-15°C), in Muntenia region. In 1961-2015 interval, below 10 frost units were recorded, which characterizes a mild winter in most agricultural areas. In central, northern and southwestern region, frost has locally recorded a moderate intensity (11 to 30 frost units / normal winter).

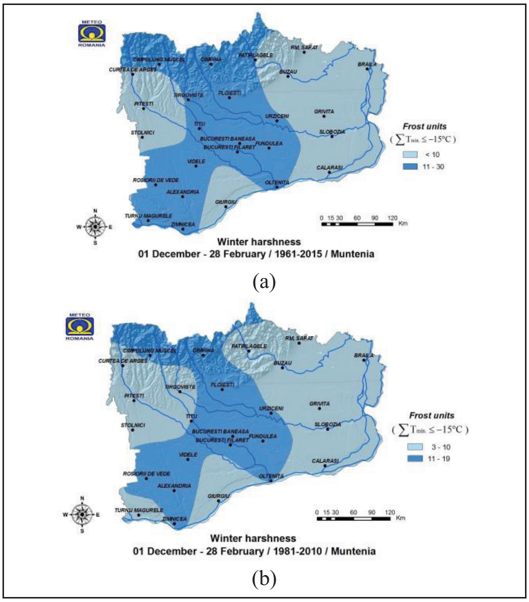


Figure 4. Frost units recorded in the December-February 1961-2015 period (a) compared to the interval 1981-2010 (b) in Muntenia Region

The frost phenomenon represents the lowering of the minimum air temperature below 0°C during the crops active growing. Late frosts cause great damage in agricultural production, especially when they occur 2-3 weeks earlier and later respectively, compared to the annual average data, landform specific. In agriculture is important to know the frost occurrence date for each crop year in order to reduce the damages through specific actions (Mateescu et al., 2016). Resulting in cell protoplasm dehydration and water freezing in tissues, low temperatures negative impact manifests itself in different ways. Winter frosts (minimum temperatures lower than -25°C) can lead to a decrease in the number of winter wheat plants or even to their complete destruction by node twinning damaging.

Repeated frosts and thaws, which typically occur during the late winter, contribute to plants uprooting. By freezing, soil water expands and raises the surface layer of soil with plants, causing breakage and node twinning plants nakedness, plants being exposed to subsequent temperature decreases in and thus to easily perish. Frosts determines not only the braking and early termination of the plant vegetation cycle development, but even their partial or total death.

Field crops are less affected by the late spring frosts, respectively by the air temperatures below 0°C in the spring season, taking into consideration the lower plant sensitivity in this season. Typically, critical moments in plants life (flowering, fructification) are occurring outside frost periods. In Muntenia Region, the muti-annual average spring-frost date for 2001-2015 interval covers the entire month of April (Figure 5).

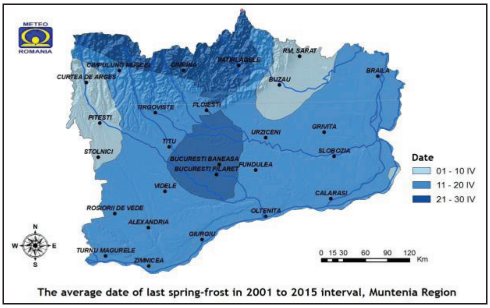


Figure 5. The average date of last spring-frost in 2001 to 2015 interval, Muntenia Region

Early autumn frosts cause damages, especially to vegetable crops (tomatoes, eggplant, peppers), the harvest of grapes and field crops which ends its vegetation period later (corn, potato, sugar beet), especially in the last 10 days of October and the first 10 days of November, for Muntenia region (Figure 6).

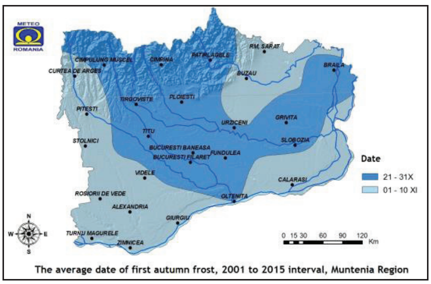


Figure 6. The average date of first autumn frost, 2001 to 2015 interval, Muntenia Region

From the 1st February to the 10th April thermal strong oscillations occur from year to year, with implications on the vegetation resumption and on the agricultural operations management. Usually, heating in February is favorable for winter wheat crops, leading to an advance in vegetation and intensively dry matter accumulation in the grain (Axinte et al., 2006).

The spring index expressed in units of heat ($\Sigma Tmed \geq 0°C$) and calculated from the 1^{st} of February to the 10^{th} of April, characterizes the potential heat in the transition period, from winter to spring season. On the entire agricultural territory of Muntenia region, in the period 1961-2015, the spring index totaled 110-301 heat units, which means a late and very late spring season (Figure 7).

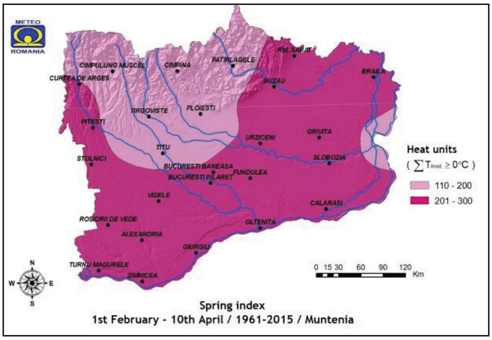


Figure 7. Spring index in Muntenia Region, 1961-2015 period

During the warm season of the year, especially in the critical period with peak water and temperature demands, a risk agro-meteorological parameter particularly important, with implications on the winter wheat production significant reduction is the heat phenomenon that can be characterized both in intensity ($\Sigma tmax. \geq 32°C$ / units of the "heat") and duration (number of days with $\Sigma Tmax \geq 32°C$). For the autumn crops, particularly in May and June, the insemination and pollination plants processes are affected by the drying plant phenomenon and the accumulation of dry matter in the grain bad is faulty, a consequence being the fact that the wheat grains are drying (Axinte et al., 2006).

The maximum air temperature values, exceeding 32°C, recorded on successive days / consecutive days (over 5 days), can lead to an earlier outbreak in the phenological phases and thus to maturation and ripening processes forcing by shortening the grain dry matter accumulation, and so producing a 10-15 days gap compared to normal dates and to actual production dates of these phases.

Figure 8 illustrates the scorching heat intensity Muntenia spatial distribution in the 1961-2015 period compared to the reference period of 1981-2010. Over the analysed period, the scorching heat phenomenon presented a high intensity (31-50 units of "heat") and accentuated (51-70 units of "heat") on extensive agricultural areas in the region. In northern and northwestern territory, moderate level of phenomenon intensity was reported (Figure 8a). In the reference period 1981-2010, the phenomenon of "heat" showed a moderate intensity (18 to 30 units of "heat") in northwestern and locally in northern part of the region. A phenomenon high intensity (31-50 units of "heat") was reported in the central and eastern region. Emphasized values the "scorching heat" (51-81 units of "heat") were recorded in the southwest and isolated southern agricultural territory (Figure 8b).

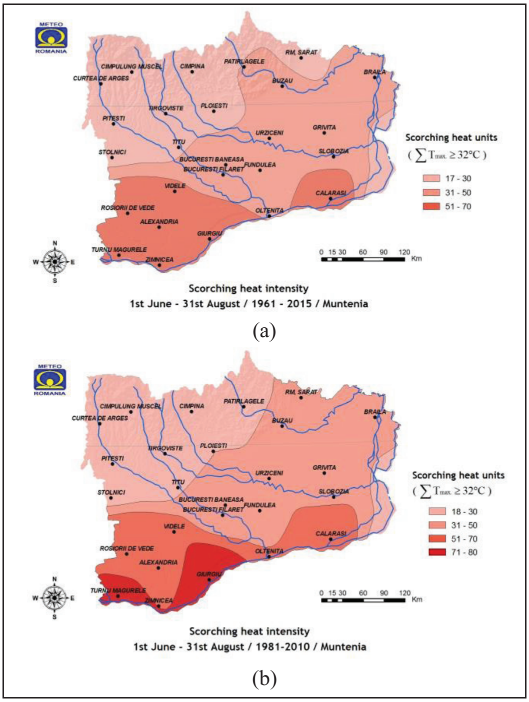


Figure 8. The scorching heat intensity in 1961 to 2015 period (a) compared to the period 1981-2010 (b), in Muntenia

In Muntenia Region, the highest values of the scorching phenomenon intensity, in the period under review, were recorded during extremely dry years 2000, 2007, 2012, 2013 and 2015, frequent at Giurgiu weather station: 203.6 units of “heat” / 2000, 222.5 units of "heat" / 2007, 296.2 units of "heat" / 2012, 275.4 units of "heat" / 2013, 135.1 units of "heat" / 2015, 132.4 units of "heat" / 2003 (Table 1), and also at Turnu Măgurele (147.8 units of "heat" / 1993, 116.1 units of "heat" / 1998, 110.4 units of ”heat” / 1962) and Roşiorii de Vede (129.8 units of "heat" / 1987) meteorological stations.

Table 1. Maximum values of "heat" units recorded at Muntenia weather stations in extremely dry years, June-August period

Year	The weather station	*Maximum values of “heat” units*
2000	***Giurgiu***	**203.6**
2001	Călăraşi	*104.7*
2002	Giurgiu	80.9
2003	Giurgiu	**132.4**
2004	Turnu Măgurele	51.5
2005	Turnu Măgurele	25.9
2006	Turnu Măgurele	65.2
2007	***Giurgiu***	**222.5**
2008	Giurgiu	*120.1*
2009	Giurgiu	84.2
2010	Giurgiu	*100.7*
2011	Turnu Măgurele	55.3
2012	***Giurgiu***	**296.2**
2013	***Giurgiu***	**275.4**
2014	Turnu Măgurele	53.9
2015	Giurgiu	**135.1**

Figure 9 illustrates the graphical representation of the average number of days with "heat" in Muntenia. There is the increase in the average number of days of "heat" (28 days), in particular from 2001 to 2015.

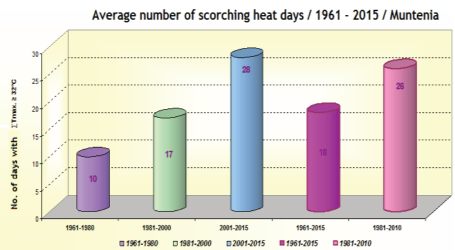


Figure 9. Scorching heat phenomenon duration during 1961-2015 period

Analyzing the rainfall amounts in Muntenia region during the autumn sowing, respectively from September to October, 1961-2015 (Figure 10a) and in the reference period 1981-2010 (Figure 10b), we can see that rainfall was optimal (81-112 mm) in most of the agricultural land.

Moderate amounts of rainfall (73-80 mm) were recorded in the eastern and southwestern region locally (Figure 10).

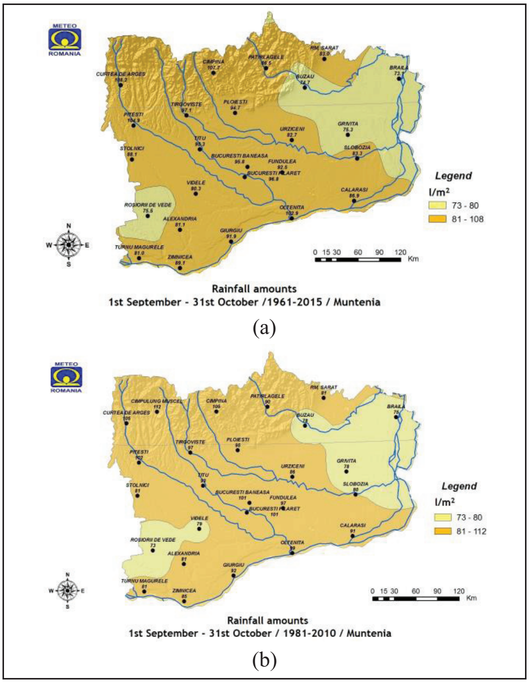
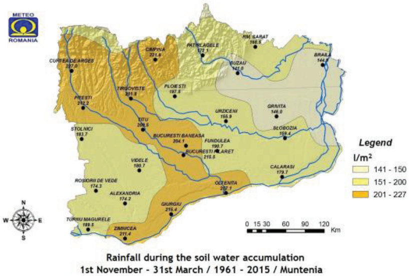


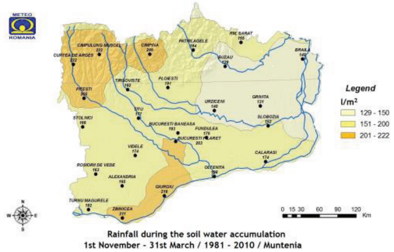
Figure 10. Rainfall amounts, September and October, 1961-2015 period (a) compared to the reference period (b), in Muntenia

During the soil water accumulation (November to March), cumulative rainfall from 1961 to 2015, were deficient (below 200 mm) compared to the optimal water requirements for the autumn wheat crop, in most parts of the region.

In the north-west and South-Muntenia local, precipitation characterizes an optimal rainfall (201-227 mm) (Figure 11).



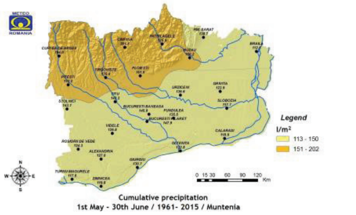
(a)



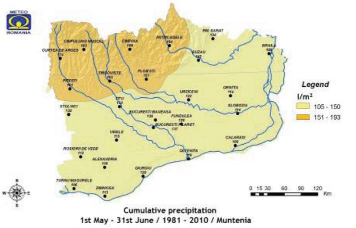
(b)

Figure 11. Rainfall during the soil water accumulation from 1961 to 2015 (a), compared with the reference range (b), in Muntenia

Rainfall during autumn wheat maximum water consumption , when plants go through earing, flowering and grain filling formation phases, from May to June, respectively 1961-2015, was deficient (113-200 mm) in most agricultural areas of Muntenia region. In northern part of the region the amounts of water (151-202 mm) were optimal (Figure 12).



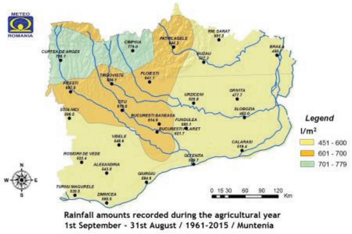
(a)



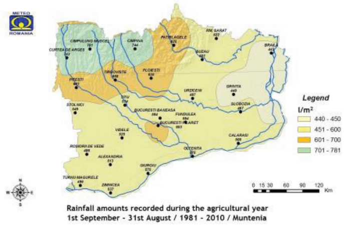
(b)

Figure 12. Cumulative precipitation in May and June, 1961-2015 (a) compared to the reference period (b), in Muntenia

In the analyzed period, rainfall amounts during the agricultural year, September to August, give the moderate drought character (451-600 mm) of rainfall in most agricultural areas of Muntenia. Optimal (601-779 mm) values of precipitation were recorded mainly in the northern part (Figure 13).



(a)



(b)

Figure 13. Rainfall amounts recorded during the agricultural year, in Muntenia, 1961-2015 (a) compared to 1981-2010 reference period (b)

In Table 2 are presented the rainfall deficit expressed as a percentage, during the extreme drought crop years 2001-2002, 2002-2003, 2006-2007, 2011-2012 and 2014-2015 (Mateescu et al., 2003) compared to the reference period 1981 -2010. The precipitation deficits vary from 83% in 2006-2007 to 116% in the agricultural year 2014/2015, with amplitude of 33%.

Table 2. Precipitation deficits of (%) during dry crop years 2001-2002, 2002-2003, 2006-2007, 2011-2012 and 2014-2015 in Region Muntenia

Agricultural year	Precipitation deficits (%)
2001-2002	89
2002-2003	92
2006-2007	83
2011-2012	92
2014-2015	116

CONCLUSIONS

At most weather stations representative for the Muntenia Region agricultural territory, the evolution of the air temperatures multi-annual value averages, in the period 1961-2015, presented a linear upward trend.

In terms of the amount of cold (from November to March) and frost units (from December to February) cumulated in the analyzed period cold season the character of normal (cold units) and mild winter (frost units) in most of the region is highlighted.

In the Muntenia region, the last spring frost multi-annual average (2001-2015) date is reached throughout April, and early autumn frosts occur especially in the last 10 days of October and the first 10 days of November.

On the whole Muntenia region agricultural area, the spring index describes a late and very late spring in the 1961-2015 period.

In the analyzed period, the “heat" phenomenon presented a high and accentuated intensity on the extensive agricultural areas in the region. The "scorching heat" intensity highest values were recorded during the extreme drought years 2000, 2007, 2012, 2013 and 2015, frequently at weather stations Giurgiu, Turnu Măgurele and Roşiorii de Vede. Especially in the period 2001-2015 are found increased average number of days with "heat".

In the period 1961-2015, based on the water optimal requirements in Muntenia autumn wheat crop, rainfall analyzed in terms of specific ranges of agricultural perspective, characterizes optimal rainfall (September-October) conditions and moderate drought (November to March, May-June and September-august).

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