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# RESEARCH REGARDING THE DEVELOPMENT OF FROST, COLD-AND HEAT-NATURAL PHENOMENA WITHIN THE AGRICULTURAL REGION "SOUTH AND SOUTH-EASTERN MUNTENIA"

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***Abstract***

*Under the circumstances of continuous change of the environment conditions by increasing global warming, decreasing rainfall and soil erosion and also under the circumstances of continuous change of the social conditions by increasing population and implicitly by increasing food and drinkable and industrial water requirements, the agriculture and the connected industry must adapt themselves to this, by using competitive techniques and technologies for being able to offer the elementary products which are necessary for ensuring economical and social development.*

*The factors which mean a major risk and negative effects for agricultural production on regional or national areas are pedological drought, flooding, heat, freeze and frost which appear within long periods of time.*

*Within this research I have analyzed the climatic temperature parameters measured within the period from 1961 till 2012 on meteorological stations which are representative for the agricultural territory of South and South-Eastern Muntenia. The data have been analyzed both from the point of view of the intensity of such natural phenomena ($\Sigma T_{max} \geq 32°C$/heat units, $\Sigma T_{min} \leq -15°C$/frost units, $\Sigma T_{med} \leq 0°C$/cold units) and from the point of view of the duration of their appearance (the number of days with heat and the number of days with frost).*

*The agricultural regions in the South of the country (which in our case means South and South-Eastern Muntenia) are agricultural territories which are vulnerable when faced with heat and frost natural phenomena and within the period of time from 1961 until 2012 there have been registered here in this regions intensity values of heat and frost natural phenomena which belong to the highest values that have been noticed in whole Romanian agricultural teritory. This means that by using the obtained information (which shows the average values of these indicators for the years contained within the period of time 1981-2012) the farmers (both the farmers who are specialized on genetic amelioration of plant species and the farmers who are specialized on mass production) may produce hybrids which are economically competitive and adapted to climacteric circumstances and stress factors (heat and frost) which are representative for South and South-Eastern Muntenia.*

***Key words**: agriculture, risk factors, temperature, heat, frost.*

## INTRODUCTION

Climate phenomena may be considered to be *risk factors* as they significantly diminish yield whenever they occur as severe manifestations at the wrong time, but mostly during critical crop development times (Sandu et al., 2010).

Major risk factors and adverse effects on regional or national agricultural production include pedological drought, flooding, intense heat, freezing and frost for extended periods (National Meteorological Administration [ANM], 2008).

The area selected for this study is one of the most important agricultural regions in Romania, with the highest yield potential despite its exposure to drought, intense heat, and frost and freezing phenomena (Dincă et al., 2012).

The winter phenomenon seen as a risk factor for the growth of autumn tree and evergreen crops is frost. Frost may adversely affect the growth of plants through both its occurrence and the intensity of the phenomenon or in relation to other climate parameters such as the absence of rain and snow protective layer, the presence of ice coating, high air humidity, strong winds, etc. (Berbecel et al., 1970).

Agriculturally and meteorologically, cold weather phenomena placing crops at risk are portrayed by abstract notions such as *winter rudeness* and *freezing intensity*.

Thermal strain indicators that adversely affect agricultural crops during the cold season are therefore *"the cold"* and *"the frost"*. They generally have an obvious spatial spreading and the degree of winter rudeness varies from one area to another according to the amount of cold and/or frost units.

Temperature/heat requirements of plants differ by species (thermophilic or mesophilic plants, etcetera) and by phenological phase (*sprouting, germination, emergence, foliation*, etcetera). Certain *thermal thresholds* (temperature ranges) specific to every genetic type of plant must be attained in order to get through each phenological phase (Chițu et al., 2013). Insufficient heat triggers delays in phenological phases or their extension (e.g. uneven emergence) and badly affects crops (Podani et al., 1998).

On the other side, excess of heat is also bad for crops and plants altogether as it inhibits metabolic processes at tissue level through excessive sweating and dehydration and through accelerated evaporation of soil water and the occurrence of pedological drought (Stoica et al., 2012). Under the circumstances, the lack of substitution irrigations during drought is directly responsible for the expansion of pedological drought, desertification and soil degradation phenomena (IPCC, 2014, et al., 2010).

## MATERIALS AND METHODS

Thermal risk phenomena for crops in South and South-Eastern Muntenia agricultural areas have been weighted based on daily temperatures measured between 1961 and 2013 at 7 weather bases belonging to the National Meteorology Agency (ANM) network, namely in Alexandria, Buzau, Calarasi, Fudulea, Giurgiu, Grivita and Turnu Magurele.

These data have been used to identify the number of days with minimum temperatures and negative average rates during the cold season (wind and frost intensity) and the number of days with maximum temperatures during the warm season (intense heat rate).

Measured values have been classified by decade (1961-1970, 1971-1980, 1981-1990, 1991-2000, 2001-2010, 2003-2102) and by 30-year intervals (1961-1990, 1971-2000, 1981-2010 and 1983-2013).

Resulting data have been interpreted by agricultural year within the 1962-2013 period and studied as follows in South and South-Eastern Muntenia:

- The amount of average air temperature rates below 0°C, ($\Sigma T_{med} \leq 0°C$, cold units) during cold season months (November-February), namely the overall quantity of "cold" accruing between the 1st of November and the 31st of March,
- The number of frost days ($T_{min} \leq -15°C$), namely the intensity of "frost" phenomenon ($\Sigma T_{min} \leq -15°C$ frost units), which phenomenon is specific to winter months (1st of December – 28th of February),
- The number of intense heat days ($T_{max} \geq 32°C$), namely the strength of the intense heat phenomenon ($\Sigma T_{max} \geq 32°C$, intense heat units) specific to the period ranging between 1st of June and 31st of August.

Depending on the target indicator, *cold units* ($\Sigma T_{med} \leq 0°C$ – November-March) or *frost units* ($\Sigma T_{min} \leq -15°C$ – December - January) during winter, the degree of rudeness or type of winter is expressed as follows (Table 1).

The study of *air temperature conditions* between November and March helps:

- Depict winters in agricultural and meteorological terms (*degree of rudeness, duration and intensity of frost)*;
- Hibernation and twinning conditions for autumn grains, the condition of tree and evergreen cultures in various cropping areas (Sandu et al., 2010).

*The 'intense heat' units* account for the difference between the highest daily air temperature and the 32°C critical threshold as aggregate values during both summer (June - August) and on a monthly basis, especially during those months when the strength and the duration of intense heat phenomenon records the highest occurrence values (Table 2).

heat units) and length (number of intense heat days).

*The 'intense heat' event* stands for a quantization of the *thermal strain* during the critical period of crops (June-August, respectively the flowering – formation and filling of grains / seeds in cereals and weeds), in terms of both strength ($\Sigma T_{max} \geq 32°C$/intense).

Table 1. Winter rudeness

| Cold intensity (freeze) $\Sigma T_{med}\leq 0^{\circ}C$ (November-March); | | Frost intensity $\Sigma T_{min}\leq -15^{\circ}C$ (December-February) | |
|---|---|---|---|
| up to 300°C cold units | mild winter<br>low intensity | up to 10°C frost units | mild winter<br>low intensity |
| 250-300°C cold units | normal winter<br>moderate intensity | 11-30°C frost units | normal winter<br>moderate intensity |
| 301-400°C cold units | cold winter<br>high intensity | 31-50°C frost units | cold winter<br>high intensity |
| 401- 600°C cold units | very cold winter<br>very high (severe) intensity | over to 50°C frost units | very cold and excessively cold winter extremely high intensity |
| over to 600°C cold units | excessively cold winter<br>unbearable intensity | | |

Table 2. Heat phenomenon

| Heat intensity $\Sigma T_{max}\geq 32^{\circ}C$ (June-August) | |
|---|---|
| Up to 10°C heat units | lack of the heat |
| 11-50°C heat units | low intensity |
| 51-70°C heat units | high intensity |
| 71-150°C heat units | very high intensity |
| ≥150°C heat units | extremely high intensity |

## RESULTS AND DISCUSSIONS

As for the pedoclimate, cropping lands in south and south-eastern Muntenia are standard plain (*Romanian Plain*) and alluvial plain (*Danube Meadow*) areas.

### 1. Frost ($\Sigma T_{min}\leq -15^{\circ}C$)

Indicators on the number of frost days and the intensity of the frost phenomenon ($\Sigma T_{min}\leq -15^{\circ}C$) have been studied for the cold season, namely the period ranging from December to January of agricultural years. The data on the multiannual average number per annum of frost days and frost units and their total number per decade is exemplifying.

It has been therefore acknowledged that the overall number per decade of frost days between 1961 and 2012 took a slightly downward path with a more obvious decrease in values during decade 1971-1980.

The most intensive frost was felt during decade 1961-1970, especially at Fundulea during the winter of 1984-1985 when not less than 21 days of minimum air temperature below -15˚C was recorded for a total of 114 frost units.

Decade 1991-2000 is characterized by the lowest frost intensity, more specifically at weather bases in Calarasi and Buzau where 1 day of less than -15 degree was recorded in average, the decennial intensity of the frost phenomenon ranging somewhere around 2 frost units.

The multiyear analysis with the results entered in Figures 1 and 2 below confirmed a downward trend of both frost day umber and frost intensity, with the last 30 years (1981-2010) being the period during which the frost phenomenon significantly decreased in intensity with values ranging from 4 to 6 annual frost units.

As for weather bases involved in the study, both frost day number and intensity during the extended period (1961-2012) appear to be at their highest at Fundulea, Alexandria and Turnu Magurele and at their lowest at Buzau, Calarasi and Grivita.

A slight decrease in the decennial evolution of the number of frost days (Figure 3) appears to be a trend in Muntenia.

Such increases turned out to be significant due to the development of this phenomenon mostly in February up to the average rate 4.5 frost days/year and 12.5 frost units/year respectively.

If we stick to the 1971-2012 period only, we notice a slight increase of the frost phenomenon and this makes the decade 1961-1970 an unusual one due to the intensity of the phenomenon in January with values far too high and out of the ordinary for the second half of the century (Figure 4).

### 2. Cold (Freeze)

As for the total decennial number of freezing days, a general downward trend was noticed with 1037 freezing days between 1961 and 1970 down to 880 days during 2001-2010. The average annual number of cold units goes to about 188 cold units, which is 19 units less than the average number for the period 1961-2103 (207 cold units).

As we may see in Figure 5, cold phenomenon intensity follows a downward path and the number of cold days lowers.

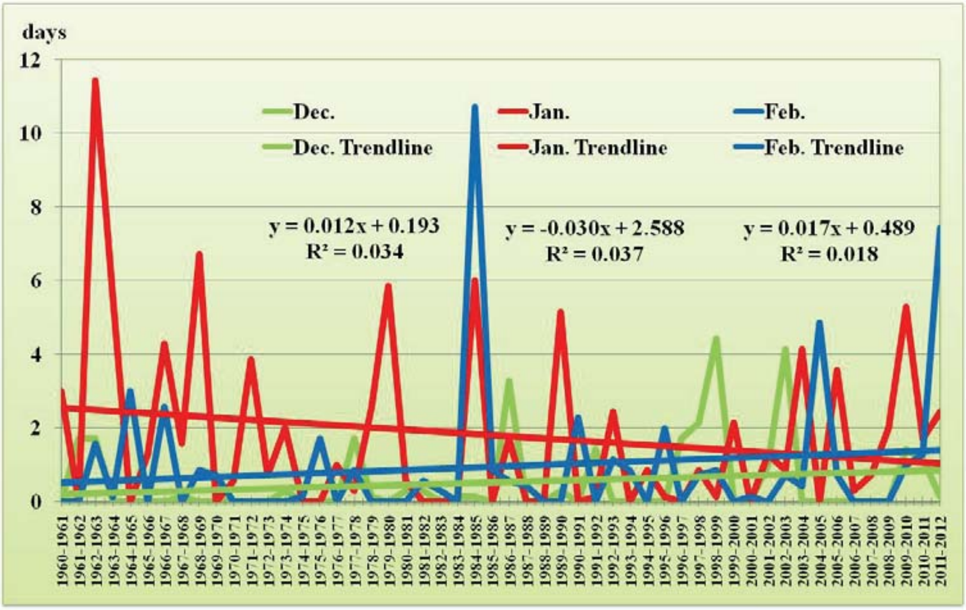

Figure 1. The annual evolution of the no. of days with frost temperature ($T_{min}$≤-15°C), in winter, between 1961 and 2012, in South and South-Eastern Muntenia

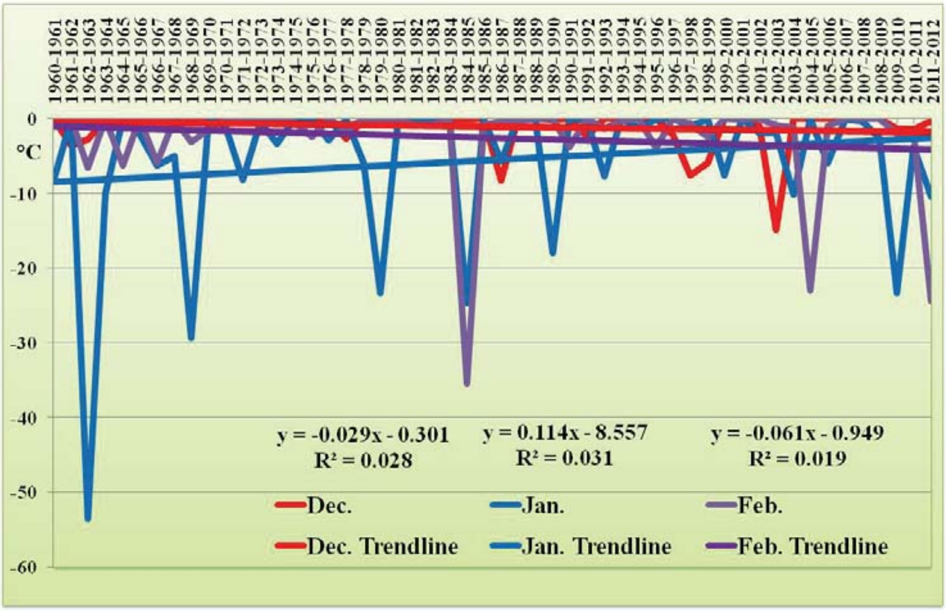

Figure 2. The annual evolution of the frost phenomenon ($\Sigma T_{min}$≤-15°C) , in winter, between 1961 and 2012, in South and South-Eastern Muntenia

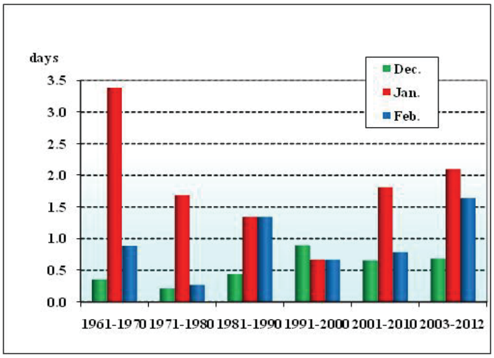

Figure 3. The decade evolution of the no. of days with frost temperature ($T_{min} \leq -15^{o}C$), in winter, between 1961 and 2012, in South and South-Eastern Muntenia

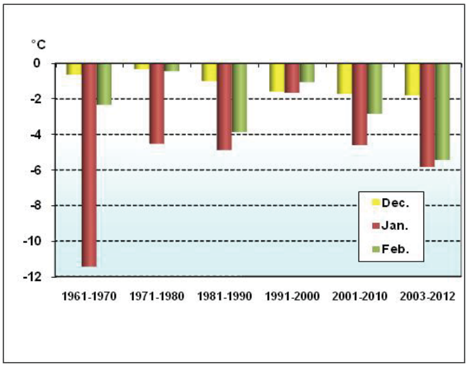

Figure 4. The decade evolution of the frost phenomenon ($\Sigma T_{min} \leq -15°C$), in winter, between 1961 and 2012, in South and South-Eastern Muntenia

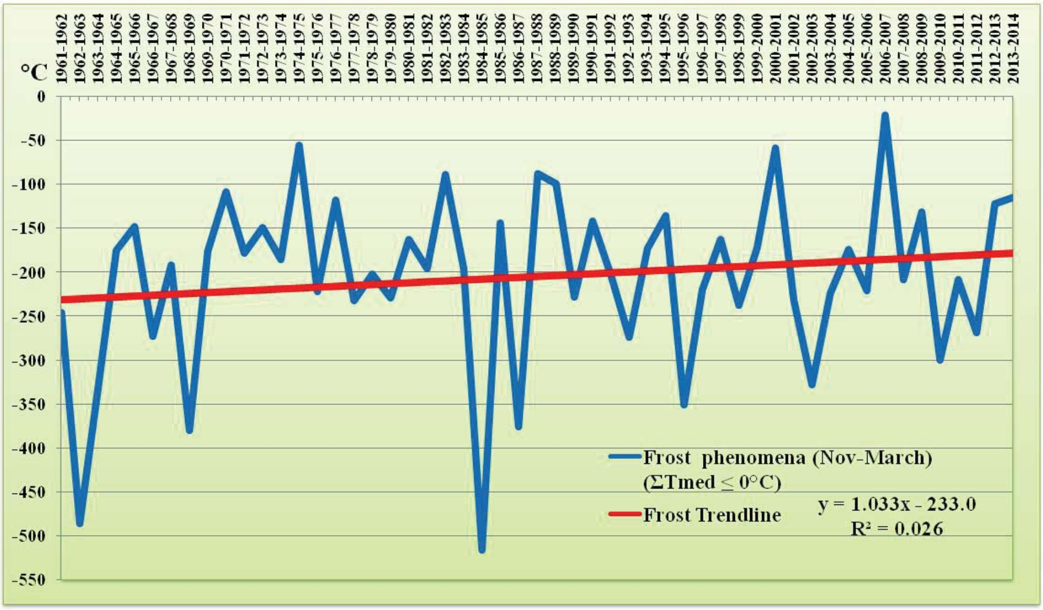

Figure 5. The annual evolution of freeze phenomenon ($\Sigma T_{med} \leq 0^{o}C$) in winter, between 1961 and 2012, in South and South-Eastern Muntenia

As for the evolution of this phenomenon every ten years (Figure 6), it followed a sinusoid curve during 1961-2012 and started with an abrupt decrease from 1961-1970 with 252 cold units down to decade 1971-1980 with 174 cold units. Later on, the freezing phenomenon recorded higher values and exceeded the threshold of 200 cold units (1981-1990), but went down subsequently to 188 cold units (1983-2012).

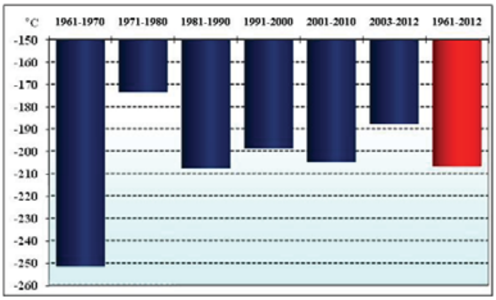

Figure. 6. The decade evolution of annual freeze phenomenon ($\Sigma T_{med} \leq 0^{o}C$), in winter, between 1961 and 2012, in South and South-Eastern Muntenia

As for the geographical spreading, the lowest number of freeze days was recorded at Calarasi and Giurgiu in southern Muntenia while the highest number Fundulea and Grivita in south-eastern Muntenia.

## 3. Intense Heat

*Alarmingly*, the number of intense heat days, namely days with the highest temperature beyond 32°C (Figure 7) doubled within the past 50 years in Muntenia. Such considerable increase of the number of intense heat days was especially acknowledged during the latest decade and mostly in July and August.

As for the evolution in *intense heat strength* ($\Sigma Tmax \geq 32°C$), it went upwards consistently and fast during the past 30 years with twice the values in July and August and very high values in 2000 (162.4 intense heat units), 2007 (173.5 intense heat units) and 2012 (103.8 intense heat units).

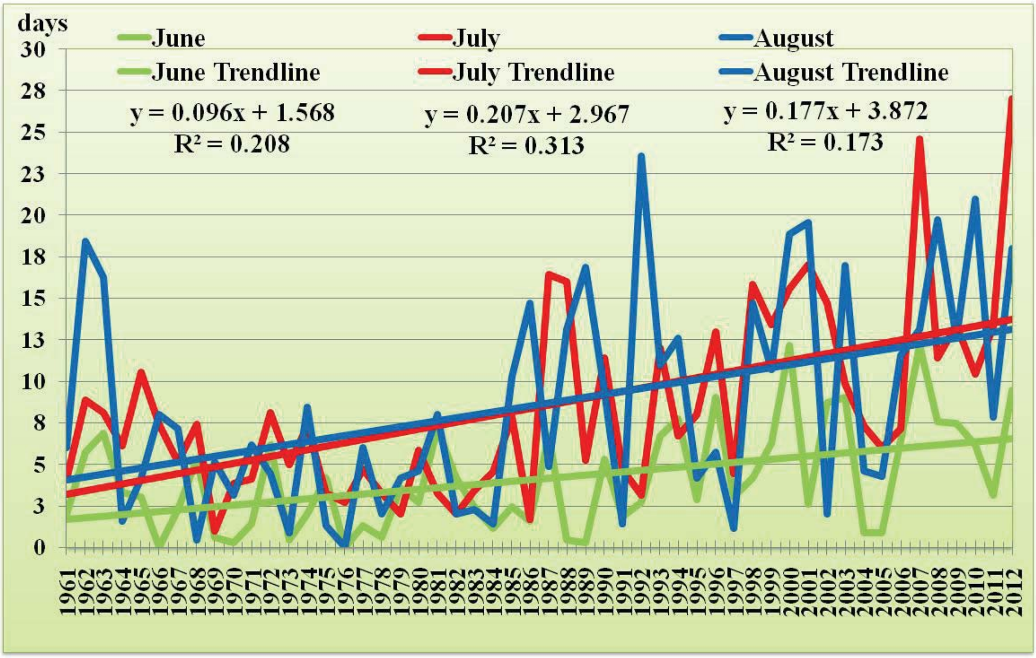

Figure 7. The annual evolution of the no. of days with intense heat ($T_{max} \geq 32^{o}C$) in summer, between 1961 and 2012, in South and South-Eastern Muntenia

In July 2007, one of the most dry years in Muntenia during the past 30 years, an aggregate value of (109°C intense heat units) was recorded which is over 5.5 higher than the average rate in the month of July within the last half-century (Figure 8).

Figures 9 and 10 indicate the decennial evolution of intense heat days and intense heat strength.

The decennial trend is a progressive one at all 7 weather bases studied in terms of both number of intense heat days and intense heat strength, as this phenomenon increased by 520% in strength over the past forty years.

The multiyear development of the annual average number of intense heat days and intense heat units highlights successive increases from one decade to another, with the highest values recorded during 1981-2010 in Giurgiu (32 intense heat units) and Turnu Magurele (31 intense heat units).

The highest values of intense heat strength were measured in 2007 at Giurgiu - namely 223°C – for a number of 61 days, as well as in Turnu Magurele - 215°C – for 58 days. On the other side, the highest annual average rates of intense heath strength between 1961 and 2010 were measured at Turnu Magurele (55°C) and Giurgiu (56°C) weather bases, and the lowest at Buzau (26.3°C) and Grivita (32.3°C) weather bases.

I also noticed that the strength of intense heat is never constant or directly proportional to the number of intense heat days. In some instances, the two indicators evolved separately as we may see from the geographical evolution of values measured at Alexandria - Calarasi and Giurgiu - Turnu Magurele weather bases.

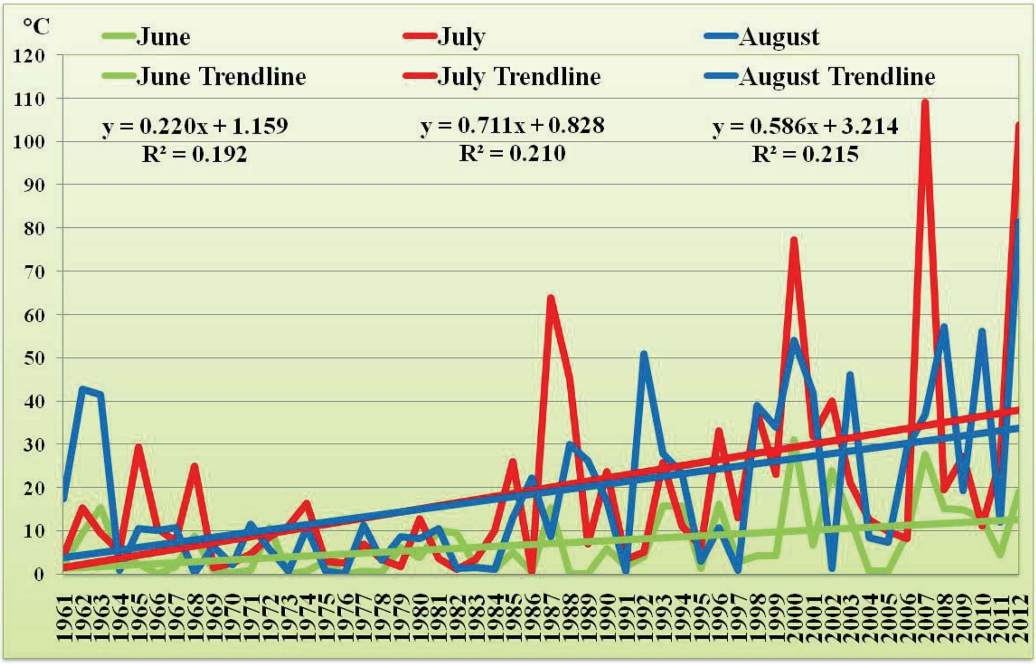

Figure 8. The annual evolution of the intense heat phenomenon ($\Sigma T_{max} \geq 32°C$), summer, between 1961 and 2012, in South and South-Eastern Muntenia

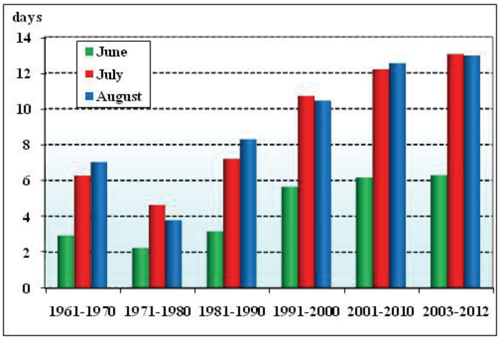

Figure 9. The decade evolution of the days with heat ($T_{max} \geq 32°C$) between 1961 and 2012, in South and South-Eastern Muntenia

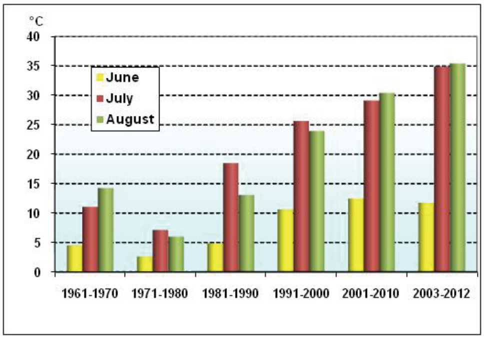

Figure 10. The decade evolution of the heat intensity ($\Sigma T_{max} \geq 32°C$) between 1961 and 2012, in South and South-Eastern Muntenia

## 4. Strain Indicator Zoning.

**The mapping** of cold and frost indicators as multiyear average rate across the agricultural Muntenia shows that the areas which are most at risk for frost lie at the heart, to the north and to the south-western part of the region where $\Sigma T_{med} \leq 0°C$ demonstrates values ranging from 200 to 300 "cold" units and $\Sigma T_{min} < -15°C$ between 11 and 30 “frost” units. They are classified as normal and moderate in intensity winter areas (Figures 11 and 12).

The north-western and eastern part of Muntenia is dominated by warmer winter climate with cold indicators between 100 and 200 "cold" units and frost indicators below 10 frost units and winters of lesser intensity.

In hilly fruit-farming areas to the north, namely at Candesti Piedmont, the climate is characterized by colder and ruder winters with cold indicators among 300 and 400 cold units and frost indicators ranging from 30 to 50 frost units.

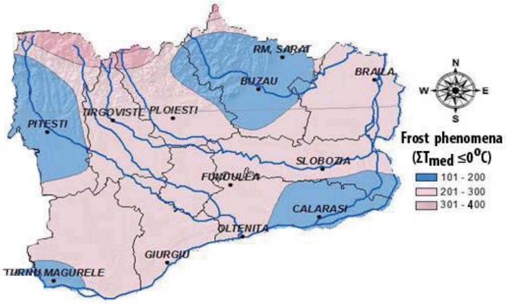

Figure 11. Muntenia cold phenomenon map (freeze)

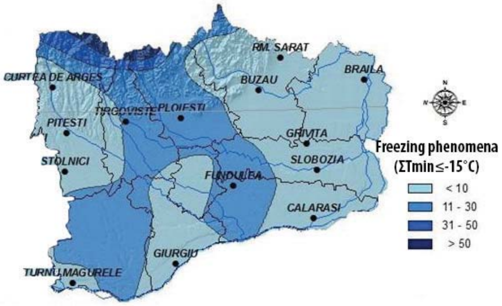

Figure 12. Muntenia frost phenomenon map

In order to assess the agricultural and weather conditions during periods with high water demand of crops (June-August), data on the intense heat strength in Muntenia have been processes. In summer (June to August), the most exposed to intense heat ($T_{max}\geq32$°C) are areas lying south of the country (Figure 13). This way, the intense heat study expressed as quantity of intense heat units (∑Tmax.≥32°C) showed that the value of „intense heat" units lowered between the 1st of June and the 31st of August / 1961-2012 (below 50 „intense heat" units) almost over the entire region. Higher intense heat strength (> 50 „intense heat" units) is still locally detected in southern Muntenia where the highest strength values have been recorded within the past 30 years (Giurgiu, Alexandria and Turnu Magurele).

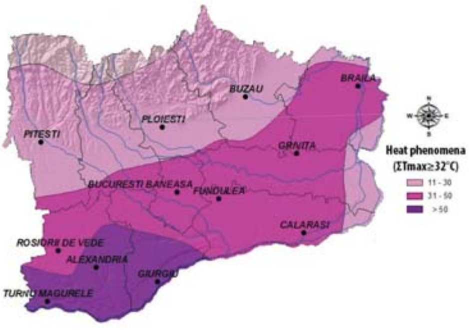

Figure 13. Muntenia heat phenomenon map

## CONCLUSIONS

Farming areas in southern Romania, namely to the south and south-east of Muntenia Region, are farming lands vulnerable to intense heat and frost where intense heat strength levels recorded during 1961-2012 were found to be the highest nationwide.

Given the known phenomenon of lower agricultural production figures due to thermal and water strain levels, we may presume that the impact of these factors on agricultural production seems to be proportionate to their intensity (2007 was among agricultural years with the lowest returns for businesses active in the plant-growing industry).

Based on the data acquired, namely the multiyear average values of these indicators between 1981 and 2000, farmers specialized in both plant species genetic improvement and mass production may establish economically-competitive hybrids adapted to weather conditions and strain factors (intense heat and frost) specific to southern and south-eastern Muntenia.

Just as a recommendation, we believe complex pedological and climate forecast studies are further required in order to identify the impact of climate changes, namely the effect of intense heat on soil quality in Muntenia, as well as to map areas exposed to climate risks in the region for regular and alternative cropping and fruit growing.

We also think fit to harmonize crop irrigation and fertilization schemes with variations produced by climate changes in the area and forecasts relying on environmental background history.

Furthermore, there is a need to develop and start growing competitive drought-hardy hybrids adapted to dryness and with a shorter yet accelerated vegetation period during periods with the best soil water reserve.

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## REFERENCES

National Meteorological Administration [ANM], 2008. Clima României. Editura Academiei Române.

Berbecel O., Stancu M., Ciovica N., Jianu V., Apetroaei St., Socor E., Rogodjan I., Eftimescu M., 1970. Agrometeorologie. Editura Ceres, Bucureşti.

Chițu E., Giosanu D., Mateescu E., 2013. Seasonal and annual extreme temperature variability and trends of the latest three decades in Romania. Advances in Environmental Sciences, 06/2013, Volume 5, Issue 2, p. 70-88.

Dincă V., Stoica G.M., Chiper A.M., Valsan G., Mandache V., Uberti M., Fierbinteanu A., 2012. Estimation of drought tolerance of local and Pioneer top comercial corn hybrids tested in different pedo-climatic areas from south of Romania. Scientific Papers Series "Management, Economic Engineering in Agriculture and Rural Development" Volume 12 – Issue 1/2012. Publishers: University of Agricultural Sciences and Veterinary Medicine Bucharest, Romania and INVEL-Multimedia SRL, p. 49-52.

IPPC, 2014, Climate Change. Available online at: http://www.ipcc.ch/report/ar5/syr/.

Podani M., Ispas St., Laurentiu D.L., 1998. Climatologie si Aagrometeorologie. Editura Domini.

Romanian Academy, The Geography Institute, 2005. Geografia României: Câmpia Româna, Dunărea, Podişul Dobrogei, Litoralul Românesc al Mării Negre şi Platforma Continentală, Editura Academiei Române, Bucureşti.

Sandu I., Mateescu E., Vatamanu V.V., 2010. Schimbari Climatice in Romania si efectele asupra agriculturii. Edituta Sitech Craiova.

Smith P., Olesen J.E., 2010. Synergies between the mitigation of, and adaptation to, climate change in agriculture. The Journal of Agricultural Science. Volume 148. Issue 05, October 2010, p. 543-552. Cambridge University.

Stoica G.M., Jinga I., Dinca V., Chiper A.M., 2012. The research in what concern the behaviour of some sunflower hybrids cultivated in irrigation conditions in Dobrogea. Scientific Papers Series "Management, Economic Engineering in Agriculture and Rural Development" Volume 12 – Issue 2/2012. Publishers: University of Agricultural Sciences and Veterinary Medicine Bucharest, Romania & INVEL-Multimedia SRL, p. 173-178.