Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development
Vol. 24, Issue 4, 2024
PRINT ISSN 2284-7995, E-ISSN 2285-3952

MANAGEMENT OF ATMOSPHERIC HEAT IN THE CONDITIONS OF WHEAT GROWTH WARMING ENVIRONMENT IN SOUTHERN ROMANIA

Cristina Elena APOSTOL[1], Roxana HOROIAȘ[2]

[1]University of Agricultural Sciences and Veterinary Medicine Bucharest, 59 Marasti, District 1, 11464, Bucharest, Romania, Phone: +40 723402021; E-mail: angelescu.cristina@managusamv.ro
[2]Probstdorfer Saatzucht Romania SRL, 20 Siriului Street, District 1, 014354, Bucharest, Romania, Phone: +40 746224204 10; E-mail: horoias.roxana@managusamv.ro

Corresponding author: horoias.roxana@managusamv.ro

Abstract

In the south part of Romania, researches were and are performed on the influence of air temperatures (of droughts) on the development, fruiting and productivity of wheat crops. The growing season of wheat varieties starts around October 10-15, they get 40-50 days in the fall to reach tillering, and then enter in the vernalization stage. It returns at the beginning of February and is harvested until July 10-15. The wheat vegetation period was, on average, for the 10 studied agricultural years (2012-2022), 236 days, out of which 50 days in autumn, 46 days in winter and 185 days in spring-summer. Our own observations and calculations highlighted the fact that there were no significant correlations between the useful spring-summer precipitation and the wheat productions obtained during the study period, nor between the varieties considered drought tolerant and the level of harvests. There was, however, a positive correlation between the time when the rain came and the vegetation phase in which the crop was at that moment – if the precipitation reappeared near the beginning of the formation of the reproductive organs, the yields could go up to 80-85% of the potential of the variety. From technological point of view, the introduction of straw or other organic residues into the soil reduced its temperature, in hot summers, by 1.5-2.0℃, when the soil moisture was below 50%. If straws were used as mulch, the reduction in soil temperature was 1.7-2.2℃. The use, by breeding, of the genes that generate desiccation grains to wheat and corn could stop plants growing during periods of severe drought and re-vegetate with the onset of moisture, but this gene transfer is not yet accepted in Europe.

Key words**:** *wheat, atmospheric heat, precipitation, yields, correlation*.

INTRODUCTION

Since 1965, the area cultivated with wheat worldwide has exceeded 200 million ha, in recent years stabilizing at around 220 million ha/year. Production, however, increased continuously, reaching approximately 765 million t [4]. Romania cultivates around 2 million ha every year, with productions between 6-8 million t/year [11]. Globally, in the years 2019-2022, stocks remained around 775 million t, and consumer demands were increasing, slightly exceeding annual production [4]. Degradation of climate conditions, through rising temperatures, generated by CO_2 pollutant emissions are among the reasons and culprits [1, 3, 13, 16].

Leaving aside the numerous crises present in the current economic and agricultural space, and which will certainly influence especially in the future the production of wheat and food in general, it is absolutely necessary for specialized research to look for solutions to avoid stagnation and relaunch growth, especially as the world's population continues to grow and consume. According to the approved literature [12, 14], the natural system of the atmosphere has in its composition 0.028-0.03% CO_2.

This very small amount, from a percentage point of view, can also be expressed as 280-300 ppm or 280-300 mg. Currently, an increase up to 400 ppm CO_2 is foreseen, an amount considered polluting. The specific gravity of CO_2 is similar to that of air, so their density is 1.205 kg/m^3.

Starting from this information, we calculated the amount of CO_2 for 1 ha cultivated with wheat, at a height of 1 m:

→ 1 m = 10,000 m^3 air = 2.8 m^3 CO_2 (normal) ⇒ 2.8 x 1.205 = 3.37 kg CO_2;
→ 1 m = 10.000 m^3 air = 4.0 m^3 CO_2 (polluted) ⇒ 4.0 x 1.205 = 4.82 kg CO_2.

The height of the atmosphere is 110 km, of which only the first 300 m correlates with the absorption capacity of plants. Correlation coefficients between height and CO_2 utilization by plants decrease from 0.78 at 0-100 m, to 0.52 at 200 m, and 0.40 at 300 m [9]. CO_2 is also found in the atmosphere at higher altitudes, but its concentration decreases by about 3.75 ppm for every 100 m of height.

Various authors [6, 15] state that the temperature of the decade 1991-2000 would be 0.14-0.57°C/year higher than in the previous decade. They also consider that, in 2020, +1°C has been reached, after which corrections follow to +0.7-0.8°C.

According to Friedlingstein et al. (2023) [7], who provide us with an annual balance of CO_2 in the atmosphere, show that during the period 2013-2022 the atmosphere was enriched by 3.3 Gt CO_2/year, a large part of this amount coming from the use of geological reserves of hydrocarbons. Agriculture also contributes 0.9 Gt CO_2/year to this increase.

Conservation of water in the soil can also be done through other processes, among which we mention the ones currently being researched:

→ creating cultivars with greater drought tolerance, using own desiccation genes [5, 8, 10];

→ use of dew water resulting from temperature differences between soil and atmosphere [2];

→ the use of protective curtains, either forest or tall plants (corn, sunflower);

→ introduction of soil loosening at 50 cm, so that water can penetrate deeply in conditions of heavy rains [2].

MATERIALS AND METHODS

In the period 2012-2022, experiences, measurements and observations were carried out in wheat crops in the south of the country (Modelu locality, Calarasi county) regarding:

→ The physiological moments that suffer the most as a result of climate changes, manifested by the presence of humidity or vegetation heat, have been determined and monitored.

→ Three tillage systems were organized to determine to what extent they can limit the physiological effects generated by soil heating. Effects on production were measured.

→ We worked on rotations with four crops, and simultaneously monitored the influence of the environment (drought, temperatures, etc.) on the symbiotic fixation of nitrogen in the soil, as an alternative to the use of synthetic nitrogen, which has become extremely expensive.

→ Four varieties of wheat, one of rapeseed, a corn hybrid and a pea variety were used - the pea was the predecessor of the wheat and the rapeseed of the corn.

→ The meteorological data were collected through the own weather station, and the moisture determinations of the samples were made in the own ovens for the period 2016-2022. The Calarasi Weather Station was also contacted to complete the data (years 2012-2015).

→ The technology used was the usual one at the farm level, and the calculation and interpretation of the data was carried out statistically by dispersion analysis and ratios (r2) and correlation functions.

To determine the amount of carbon, combustion is carried out in ovens (furnaces) or spectrophotometric methods are used. In both wheat straw and corn, canola and sunflower stalks, the carbon content is C = 42-44% or C = 0.42-0.44. This also applies to roots. Up to 45-47% carbon can be found in wheat grains, depending on their carbohydrate content.

To simplify the calculations, we can consider C = 0.44, which is the carbon in dry biomass, at constant weight. For a production of 6,000 kg of wheat and 7,000 kg of straw per ha (ratio 1:1.16), the total amount of carbon extracted is:

13 x 0.44 = 5.72 t C/ha = 20.9 t CO_2/ha wheat

RESULTS AND DISCUSSIONS

Figure 1a and 1b show the annual averages of temperatures and the amount of precipitation during the years of experimentation, 2012-2022. Comparing the two graphs, we observe a negative correlation between the volume of precipitation and atmospheric temperatures, a normal phenomenon in a forest-steppe climate zone. The annual temperature variations did not indicate to us, through the figures provided, reasons to observe significant climate change influences.

Even in the driest years (2016, 2019, 2020 and 2022), monthly temperatures during flowering and grain filling did not exceed 30°C (May and June), so we cannot have evidence of climatic deviations on this parameter.

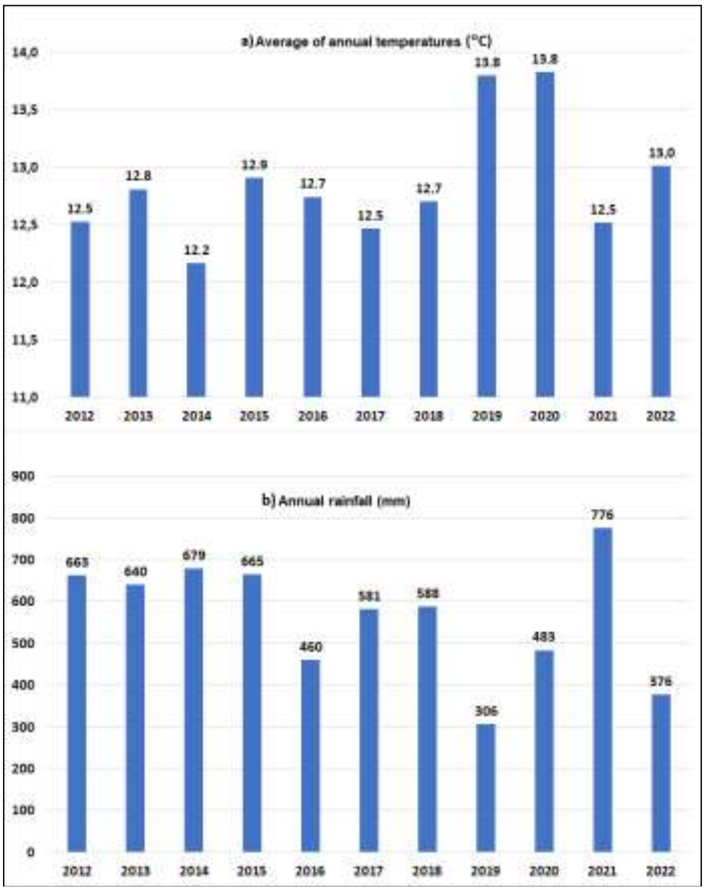

Fig. 1. Average annual temperatures (a) and annual precipitation (b) recorded in the experimental field during 2012-2022
Source: Own original data.

Precipitation, in most years, was well above average. The most frequent rains were recorded at the end of June and during July, preventing the harvest and forcing the crop to offer a smaller yield and of poorer quality. A series of correlation analyzes were undertaken to enable us to ascertain which of the rains were most favorable to the wheat crop, which were favorable and why.

It should be noted that in all the years of research (2012-2022), the initial soil moisture was deficient, without exception. The existing water reserve in the soil at wheat sowing was between the withering coefficient (in the fall of 2020) and 50-150 m^3 of useful water in the other years. With few exceptions (the year 2022), the production was carried out "in anticipation", that is, in the hope of the rains.

Figure 2 shows the correlation between the average productions of the four wheat varieties analyzed and the precipitation that fell in the first part of the year, the water on which the harvest was based. There is an increasing polynomial correlation of yields and rainfall, which placed the overall average of the experiment at about 52 q/ha. All this time there was work under the specter of drought, but almost total production losses were only in the year 2020, which led us to search and find an explanation.

The enormous amplitude between the years 2020 and 2022 is observed, with a production difference of approximately 50 q/ha, in the conditions where humidity intervened decisively only in April. In the rest of the years the production settles around 52 q/ha, regardless of whether 100 or 300 mm of precipitation fell in the summer wheat season. It depends a lot on when and how the rains fall. Sequencing the rainfall regime, Figure 3 shows the correlation between the rainfall in April-July and the harvest level. We encounter the same situation at a correlation ratio of 0.54. The phenomenon is repeated for two months, namely the months of April and May, according to the model in Figure 4, which expresses the correlation between the precipitation that fell exclusively in the month of April and the wheat production achieved, with a fault indicating the collapse of the 2020 harvest (0.9 - 20 .0 q/ha).

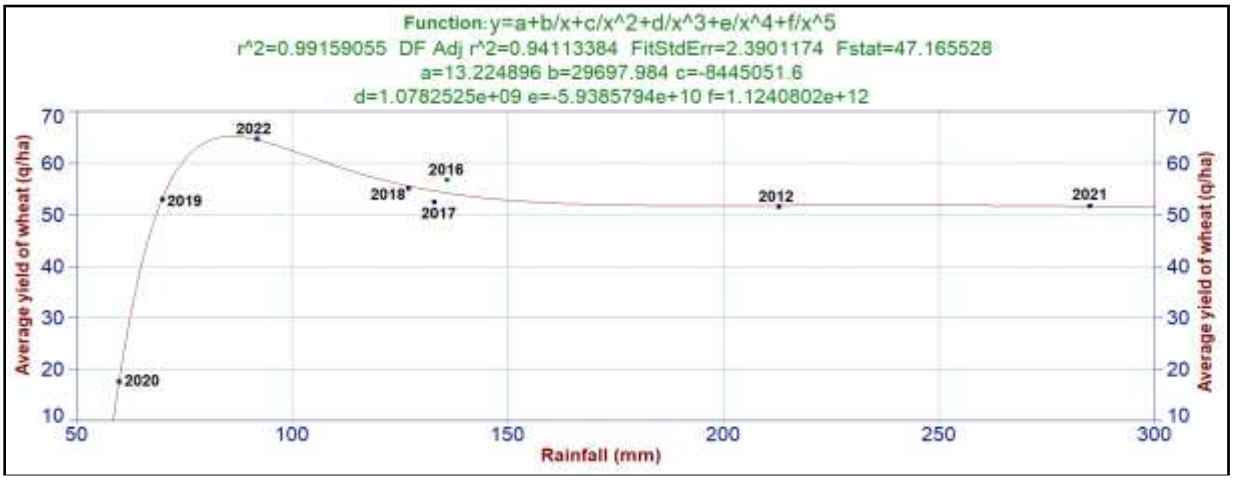

Fig. 2. Correlation between wheat production (average of 4 varieties) and rainfall in the months of January-April 2012-2022 in the research field - Modelu, Calarasi county
Source: Own original data.

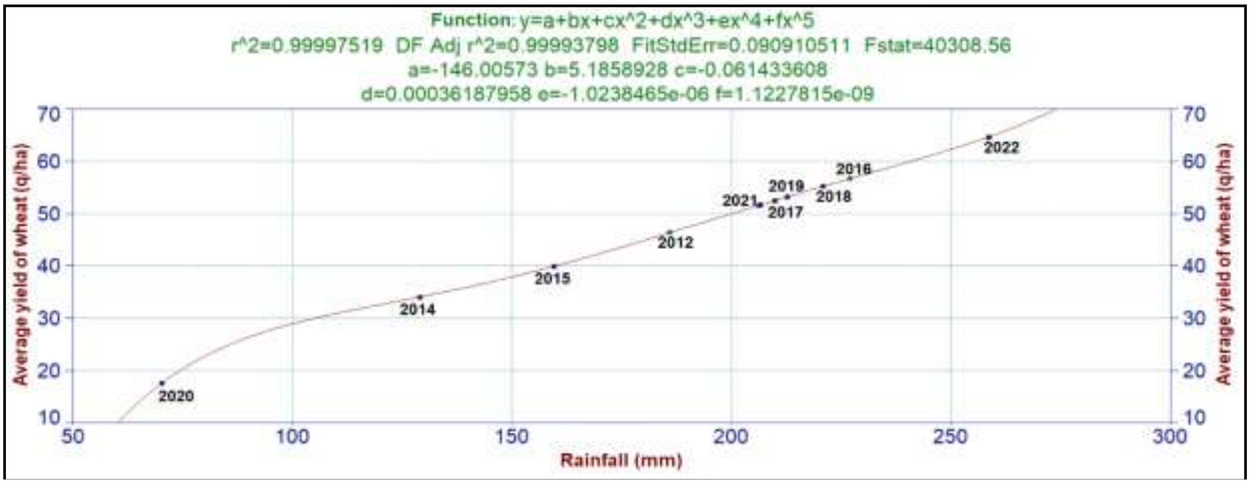

Fig. 3. Correlation between wheat production (average of 4 varieties) and rainfall in the months of January-July 2012-2022 in the research field - Modelu, Calarasi county
Source: Own original data.

PRINT ISSN 2284-7995, E-ISSN 2285-3952

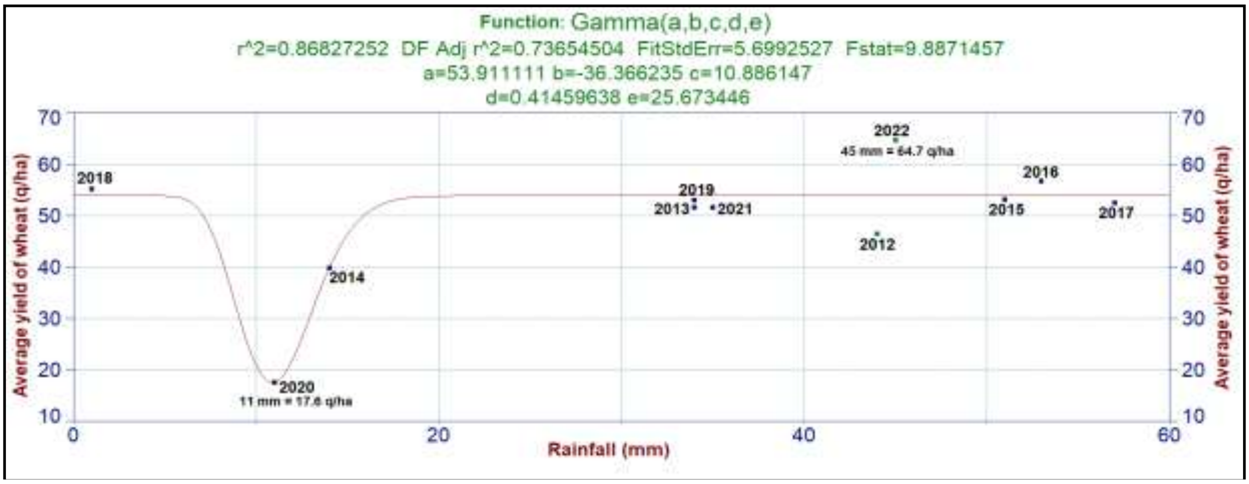

Fig. 4. Correlation between wheat production (average of 4 varieties) and rainfall in April of the years 2012-2021 in the research field - Modelu, Calarasi county
Source: Own original data.

Similar to the other graphs, except for this year, the average yields remain constant for the four varieties, with sometimes significant variations from one variety to another. This is also the reason why it is recommended in agricultural practice to use several winter wheat varieties for grain wheat crops.

Figure 4 confirms the other calculations and observations, showing that the lack of rainfall in April will lead to a drastic drop in wheat production. The statistical processing of the data is supported by a very high correlation ratio (r^2 = 0.8682), which indicates a determination of 86.8%, which is the probability of repeatability of the results, against the background of the same external factors.

Resuming the analysis of the state of soil moisture, we found that the sudden decreases in yield in all varieties studied in 2020 were generated by:

-the very low rainfall in the fall of 2019, which did not allow wheat plants to sprout in the fall;

-the maximum frequency of sunrise occurred in December 2019 – January 2020 (warm months) and was mainly due to the reduced rains of November-December 2019 and spring rains (46 mm);

-vernalization was carried out due to the low temperatures in the first part of February and partly in March;

-in the second part of April, the plants were supposed to go into the reproductive phase, but exactly then there was no water in the soil reserve and there were no rains either (11 mm in April);

-the return of precipitation in May and June was late;

-the lack of precipitation in April, against the background of a reserve of water in the soil very close to the withering coefficient, led to the compromise of the crop, even if after that there was water from the precipitation.

A similar situation was that of the 2021-2022 agricultural year, when the water reserve was slightly higher, but spring precipitation was lacking. In March, for example, it rained only 3 mm. In contrast, April, when plants need sufficient moisture to activate the winterization-to-flowering switch, brought 45 mm of precipitation. The physiological-genetic phenomenon was supported, then, by the precipitation in May and June, decisive for filling the grain, and the production was the highest in this series of years of experimentation, respectively 64.7 q/ha, on average.

Big problems could also have been created in April 2018, in which no rain fell at all, but it benefited from a water reserve of about 60%, generated by the rains that fell especially in autumn 2017 (over 190 mm) and spring 2018 (130 mm).

From these observations it emerged that, in order to ensure water moisture in the soil at the time of wheat plants transition from vegetative to reproductive growth, the specific consumption of the crop can decrease by

Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development
Vol. 24, Issue 4, 2024
PRINT ISSN 2284-7995, E-ISSN 2285-3952

about 10-50%, depending on the thermal conditions, especially those after blooming.

Through the three systems of works, followed for 10 agricultural years (2012-2022) in the southern part of Romania, we looked for solutions to conserve water in the soil, to maintain crops. In order to observe the differences, we performed periodic, comparative measurements.

From Table 1 it can be seen that in November (average for the entire interval), at the depth of 30 cm, compared to the conventional system, soil mulching brings temperatures higher by 1.7°C, while the incorporation of organic matter gives +0 ,9°C. Similarly, +1.2°C and +0.6°C were recorded in May, and +1.5°C and +1.4°C in June. The precursor plant was canola, and the incorporated biological material was canola stalks. By comparing the three work systems, it was observed that an increase of 113 m^3 water/ha was obtained in the version with incorporation and 238 m^3 water/ha in the system with mulching, according to the measurements made in October. For the month of March, the differences compared to the control are significantly higher, respectively +400 m^3 water/ha in the system with the incorporation of biomass and +538 m^3 water/ha in the case of mulched soil.

The effect of special works on the level of productions was not spectacular. Production increments do not overcome random environmental variations.

Table 1. The influence of the tillage system on the soil temperature at a depth of 30 cm and on the useful water reserve in Modelu - Calarasi county

Crt.	Working system	Soil temperature at 30 cm depth		
		November	May	June
1.	Conventionally tilled soil	mt 7.2	16.4	23.2
2.	Soil worked with minimum tillage – chopped straw introduced into the soil	0.9 mt 8.1	0.6 17.0	1.4 24.6
3.	Uncultivated mulched soil - straws remain on the surface	0.8 mt 8.9 (1.7)	0.8 17.6 (1.2)	24.7 (1.5)

Useful humidity = 1875 m^3/ha

Crt.	%		t/ha useful water		Average yield(q/ha)		
	October	March	October	March	$\overline{m}$	Dif.	%
1.	6.1 20.1	4.1 19,1	762	512	54.0	Mt.	-
2.	7.0 22,0	7.3 22,3	+ 113 875	+400 912	54.6	0.6	+1.1
3.	8.0 23,0	8.4 23,4	+ 238 1000	+538 1050	55.1	1.1	+2.0

Source: authors' calculations, based on results obtained in experimental fields.

On average, production increased by 1.1% when incorporating plant residues and by 2.0% when mulching. There was a more visible tendency to increase yield only in the first 2-3 years, after which prolonged droughts, but also the appearance of dangerous pests, such as mice, led to a new conclusion, namely that the two alternative systems are very good, provided they are not permanent.

CONCLUSIONS

The main conclusions of our own research are the following:

-The climate changes announced for several decades and generated by the increase of CO_2

in the atmosphere, in the conditions of wheat cultivation in the south of the country (Calarasi area), did not lead to significant changes in the evolution of growth, development and production of premium wheat varieties.

-The amount of CO_2 absorbed by the wheat crop from the atmosphere is about 440 kg/t grain and straw (together), provided that the grain/straw ratio is 1:1. A production of 5 t grains + 5 t straw absorbs 4.4 t CO_2 or 1.20 t C.

-CO_2 emissions into the atmosphere represent 1/3 of absorption and are due to respiration, to which carbon stored through harvesting is partially added = 0.45 (P).

-The final balance is favorable for wheat cultivation, even under classic tillage conditions. The tillage system, on average over 10 years, insignificantly influences the accumulation of water and heat in the soil and environment. Covering with mulch is more conducive to keeping the soil warmer, especially in colder periods.

-Soil drought significantly affects wheat production, especially if it occurs during the "double crest" phase of the transition from the vegetative to the reproductive phase. It is important to find sources of water supply, especially in this phase, which is most frequently encountered in the 2nd and 3rd decades of April.

REFERENCES

[1]Addy, J.W.G., Ellis, R.H., Macdonald, A.J., Semenov, M.A., Mead, A., 2021, The impact of weather and increased atmospheric CO_2 from 1892 to 2016 on simulated yields of UK wheat, Journal of the Royal Society, Interface, 18:20210250.

[2]Berca, M., Robescu, V.-O., Horoiaș, R., 2021, Winter wheat crop water consumption and its effect on yields in southern Romania, in the very dry 2019-2020 agricultural year, Notulae Botanicae Horti Agrobotanici Cluj-Napoca, 49(2):12309.

[3]Blandino, M., Badeck, F.-W., Giordano, D., Marti, A., Rizza, F., Scarpino, V., Vaccino, P., 2020, Elevated CO_2 impact on common wheat (*Triticum aestivum* L.) yield, wholemeal quality and sanitary risk, Journal of Agricultural and Food Chemistry, 68(39):10574-10585.

[4]FAO, 2022, Agricultural production statistics, 2000-2020, FAOSTAT Analytical Brief Series No. 41, Rome.

[5]Farrant, J.M., Cooper, K., Dace, H.J.W., Bentley, J., Hilgart, A., 2017, Dessication tolerance, In: Plant stress physiology, 217-252.

[6]Florides, G.A., Christodoulides, P., 2009, Global warming and carbon dioxide through sciences, Environmental International, 35:390-401.

[7]Friedlingstein, P., O'Sullivan, M., Jones, M.W., Andrew, R.M., Bakker, D.C.E., Hauck, J., …, Zheng., B., 2023, Global Carbon Budget 2023, Earth Syst. Sci. Data, 15, p. 5301-5369.

[8]Hilhorst, H.W.M., Farrant, J.M., 2018, Plant desication tolerance: a survival strategy with exceptional prospects for climate-smart agriculture, In: Annual Plant Reviews Online, 1(2):0637.

[9]Li, Y., Deng, J., Mu, C., Xing, Z., Du, K., 2014, Vertical distribution of CO2 in the atmospheric boundary layer: characteristics and impact of meteorological variables, Atmospheric Environment, 91:110-117.

[10]Morran, S., Eini, O., Pyvovarenko, T., Parent, B., Singh, R., Ismagul, A., Eliby, S., Shirley, N., Langridge, P., Lopato, S., 2011, Improvement of stress tolerance of wheat and barley by modulation of expression of DREB/CBF factors, Plant Biotechonological Journal, 9(2):230–24.

[11]National Institute of Statistics, NIS, Tempo-online – AGR109A – Agricultural vegetal production by main crops, form of ownership, macroregions and counties (Producția agricolă vegetală la principalele culturi, pe forme de proprietate, macroregiuni, regiuni de dezvoltare și județe), Accesed on September 5, 2024.

[12]Olivier, J.G.J., Peters, J.A.H.W., 2020, Trends in global CO_2 and total greenhouse gas emissions: 2019 Report, PBL Netherlands Environmental Assessment Agency.

[13]Popescu, A., Dinu, T.A., Stoian, E., Șerban, V., 2023, Climate change and its impact on wheat, maize and sunflower yield in Romania in the period 2017-202, Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development, Vol.23(1), 587-602.

[14]Slocum, G., 1955, Has the amount of carbon dioxide in the atmosphere changed significantly since the beginning of the twentieth century, Monthly Weather Review, 83:225-231.

[15]Solomon, S., Plattner, G.-K., Knutti, R., Friedlingstein, P., 2009, Irreversible climate change due to carbon dioxide emissions, Environmental Sciences, 106(6):1704-1709.

[16]Zhang, H., Tang, Y., Chandio, A.A., Sargani, G.R., Ankrah, T.M., 2022, Measuring the Effects of Climate Change on Wheat Production: Evidence from Northern China, International Journal of Environmental Research and Public Health, 19:12341.