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STUDY OF THE RELATIONSHIP BETWEEN CLIMATIC CONDITIONS AND WHEAT PRODUCTIONS DURING 2020-2024 AT SCDA CARACAL

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Abstract
Although Romania's climate is known as "moderate continental", in recent years extremely large variations have occurred (total amount of precipitation from one year to another, its distribution throughout the year), which determines water deficits frequently associated with heat during the growth and development of wheat on the chernozem of Caracal. To study the variability of some of the characters involved in drought resistance of winter wheat, 220 common wheat varieties of different origins were used. The presentation of the pluviometric regime was made based on the Angot index, an index that expresses how rainy the month is in relation to the overall precipitation in a year.
The frequency of months was determined according to the drought intensity classes. Based on the average yields obtained in the period 2020-2024, a restricted common assortment was established. Starting from this, were analyzed the relationship between the average yield and the Angot index, the reaction of varieties to contrasting water supply conditions, the interaction of temperatures x precipitation in the May-June period (Triboi model, 2008) and the influence of water stress on production, productivity elements (number of grains/ear, weight of grains/ear, TKW) and production quality (TW, protein).

Keywords: Angot index, drought, limited variety, production, wheat.

1. INTRODUCTION

In arid and semi-arid areas, abiotic stress is the most important limiting factor in production due to reduced water availability (Bhandari et al., 2021; Lehari et al., 2019).
Wheat crops require 300-500 mm of water, which is much higher than the water requirements of other crops. Drought reduces wheat yields by an average of 50-60% (Poudel et al., 2020).
Drought accompanied by high temperatures represents a major danger for the formation of productions, Romania registering changes in the thermal regime in agreement with the global context of climate change. Climate warming is a phenomenon widely accepted by the international scientific community, as already pointed out by analyzing observational data over long periods of

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time. Romanian researchers' studies have helped refine the region projection methodologies in order to predict global warming (Iordan, 2015).

Wheat (*Triticum aestivum* L.) is one of the oldest cultivated plants in the world and has always been one of the most important staples for many countries (Yue et al., 2019). Due to variations in climate, biotic, and abiotic stresses, there are demands for the adaptation of wheat varieties with different phenotypic traits (Bonciu, 2019; Ișlicaru et al., 2021; Paunescu et al., 2024).

The climate is changing globally at an unprecedented rate and agriculture is one of the most vulnerable sectors to this change (Demirhan and Bayraktar, 2025). Having a leading role in food security and livelihoods, the impact of climate change on wheat production draws significant attention (Zhai et al., 2017; Zhang et al., 2022). Among the factors adverse to wheat cultivation, drought, i.e. the lack of adequate moisture for crop formation, has a significant limiting effect that can exceed the level of negative impact exerted by all other cumulative abiotic factors (Barnabas et al., 2008).

Drought induces reduced germination, seed vigor, seedling vigor, leaf area, early leaf wilting, decreased dry biomass, increased root-to-stem ratio, and early maturity (Anjum et al., 2017). Seed germination plays a crucial role in crop establishment, development, and production (Almansouri et al., 2001). Lack of soil water prevents or delays seed germination, leading to uneven and consequently reduced wheat grain production (Hossain et al., 2016).

Drought reduces leaf area. Lack of water decreases nitrogen uptake by plants, which causes nitrogen to be remobilized from leaves and stems to seeds, causing early leaf drying (Hajibarat and Saidi, 2022). Plants, in their continuous search for water, develop their roots in the soil, which helps them absorb more water from deep in the soil under drought stress, leading to an increase in the root-to-stem ratio (Kou et al., 2022).

Based on climate simulation models, Ozdogan (2011) finds that higher CO_2 levels and temperatures and lower precipitation would reduce wheat yields between 5% and 35% in the Northwestern part of Türkiye. Dellal and Unuvar (2019) using economic analysis and biophysical models indicate that climate change is expected to decrease yields in major crops up to 10.1% in 2050. The 2019 study extends the results and finds out that yield reductions will be 2%–7% in 2020, 4%–12% in 2050 and 5%–20% in 2080 (Demirhan and Bayraktar, 2025).

Drought accompanied by high temperatures represents a major danger for the formation of productions, Romania registering changes in the thermal regime in agreement with the global context of climate change. Without having a very rigorous cyclical character, in the previous century the drought phenomenon generally occurred at intervals of 10-15 years (Halbac and Halbac, 2021).

In recent decade, global efforts have been increasing to develop climate resilient varieties to protect wheat production. Improving drought tolerance through the use of new genetic resources is the most important strategy for overcoming climatic conditions around the world and achieving high wheat yields (Hussain and Jatoi, 2021).

2. MATERIALS AND METHODS

The presentation of the rainfall regime for these years was based on the Angot index, an index that expresses the more or less rainy character of a month in relation to the overall precipitation in a year. The coefficient is higher or lower than 1.

The index is calculated as follows:

- For months with 31 days (31/365 = 0.085) q = 11.76 p/P;

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- For months with 30 days (30/365 = 0.082) q = 12.19 p/P;
- For months with 28 days (28/365 = 0.077) q = 12.99 p/P.

This index highlights how the month is in terms of rainfall in relation to the annual average of the respective location. But in a location with 2000 mm per year a month in which 60 mm of precipitation was recorded is considered arid, in a location with an average of 400 mm it is humid.

In our case, the Angot index was modified in the sense that P was considered the multiannual average calculated for 37 years (fixed amount of 537.8 mm) and not the precipitation that fell in that year, because we wanted to highlight how the month studied was in relation to the general characterization of the area in terms of climate.

Production was determined by harvesting 5 m^2 from each experimental plot, and the calculation was made by bringing it to the standard humidity of 14%.

During the period 2020-2024, the precipitation during the vegetation period was as follows: 2020 – 458.8 mm, 2021 – 640.8 mm, 2022 – 394.8 mm, 2023 - 576.8 mm, 2024 – 452.4.

3. RESULTS AND DISCUSSIONS

Based on the Angot index and taking into account the fact that a sub-unit index represents a dry month and a super-unit index represents a rainy month, the frequency of months in the period 2020-2024 for Caracal was calculated (Table 1).

Following the analysis, out of a total of 72 months, the dry and very dry months represented 73.6% of the total months analyzed.

The yields obtained most accurately described the favorability of these conditions.

Throughout the entire period 2020-2025, yields fluctuated greatly, with the average for the varieties tested in all years ranging from 6846 kg/ha in 2003 to 11040 kg/ha in 2020 (Table 2).

Lower yields were associated with drought conditions in autumn (uneven emergence) and the yellow rust attack manifested in 2023.

On the chernozem of Caracal, in the five years of experimentation the most productive variety was Anapurna with an average of 10180 kg/ha and the lowest yield was recorded by Bezostaia – 5620 kg/ha. This is the oldest variety in the collection, kept especially for the calculation of genetic progress. The 36 varieties that make up the limited assortment are the varieties that were tested in each year of the 5 years of experimentation.

Table 1. The frequency of the months according to the classes of drought intensity in 2020-2024 period at Caracal

Drought intensity class	Angot index	Absolute frequency (no. of months)	Relative frequency (%)
Very dry months	Below 0.99	41	56.9
Dry months	1-1.49	12	16.7
Moderate months	1.5-1.99	6	8.3
Wet months	2-2.49	10	13.9
Very wet months	Over 2.5	3	4.2
Total		72	100

There was no correlation between the average production of the varieties tested throughout the period and the average Angot index, which suggests that there were other causes that reduced production, apart from climatic conditions, as previously mentioned, the strong attack of yellow rust in 2023 (Figure 1).

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Table 2. The average yields obtained during the period 2020-2024 on the limited set of cultivars

Variety/Year	2020	2021	2022	2023	2024	Average 2020-2025
ABUND	12245	11151	8374	5670	6756	**8839**
ADELINA	10180	10240	8293	7243	5921	**8375**
ANAPURNA	12977	12037	7885	9586	8415	**10180**
AVENUE	11965	11065	7200	8715	8604	**9510**
BASILIO	11876	11062	7553	7513	7721	**9145**
BEZOSTAIA	6594	8418	5897	2916	4276	**5620**
BIHARIA	11783	10314	7602	4303	5407	**7882**
BOGDANA	11573	11941	7607	7117	8636	**9375**
BOLOGNA	10911	9894	6695	7138	6487	**8225**
DACIC	11112	10387	7940	3073	8214	**8145**
EXOTIC	11329	9655	7740	6981	10317	**9204**
FALADO	10661	8257	7155	7604	8492	**8434**
FLAVOR	12907	10447	7085	8896	7952	**9457**
GABRIO	9831	10084	8795	7963	8574	**9049**
GLOSA	11025	8833	8593	4617	6983	**8010**
IZALCO	10811	8511	6953	8273	6543	**8218**
IZVOR	11032	8648	7463	3838	5928	**7382**
MIRANDA	10480	9831	7579	3187	7411	**7698**
OTILIA	10261	9163	7671	4907	6779	**7756**
PIBRAC	12942	10688	7761	8452	8953	**9759**
PITAR	10350	9548	7302	4732	6670	**7720**
RUBISKO	7974	10183	7282	8932	7282	**8331**
SEMNAL	10514	10522	7732	6766	6420	**8391**
SILVERIO	10903	9142	7224	7732	9345	**8869**
SOFRU	12276	10044	8063	9290	7343	**9403**
SOLEHIO	11152	8457	7484	7327	7882	**8460**
SOLINDO	13391	9862	8786	9334	7461	**9767**
SOMTUOSO	12596	9505	7968	10181	6465	**9343**
SORRIAL	8735	8987	6953	7146	7391	**7842**
SOSTHENE	11961	9662	7395	7510	8730	**9052**
SOTHYS	13128	10716	7753	7663	7751	**9402**
SY PASSION	12726	11575	9034	8480	7747	**9912**
SY ROCINANTE	13843	11709	8043	9221	7145	**9992**
SY STARLORD	11285	11012	7979	8770	7471	**9303**
URSITA	12113	12306	8365	5282	7290	**9071**
VOINIC	11022	10161	7782	4907	7073	**8189**
Average of the 36 varieties	**11040**	**9893**	**7541**	**6846**	**7293**	

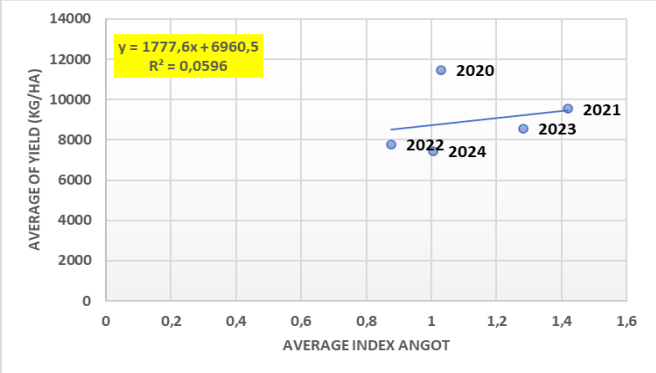

Figure 1. The relationship between average yield of the varieties tested in the period 2020-2025 and the average index Angot

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A simple classification of the productions obtained according to favorability (2021 – favorable year, 2022 – unfavorable year for wheat cultivation) and the calculation of losses expressed in percentages provide us with a series of information on the productivity and stability of the varieties that were cultivated in these two years (Figure 2). Only 115 varieties out of the 220 were tested in both the favorable and unfavorable year. In 2021, the sum of precipitations during the vegetation period was 640.8 mm and in 2022 – 394.8 mm.
The difference in production between the two years ranged from non-existent to 44.6%. It should be noted that the 11 varieties classified in the class of the lowest losses: KATARINA, KRALICA, INGENIO, MOBILE, MODERN, GLOSA, OBIWAN, COMPLICE, FOXIL, MUSIK, KLIMA did not have productions over 10,000 kg/ha in the favorable year.
Among the varieties of group II, CENTURION, MONTECRISTO, GABRIO, AURELIUS, MOISSON, PROVIDENCE, PYTHON and SOFRU stood out, which although they had productions over 10,000 kg/ha in the favorable year, had losses below 20%.
Three quarters of the varieties with losses of 30-40% had productions over 10,000 kg/ha or even 12,000 kg/ha. The variety with the highest loss was TARASCON with 44.6%. Its production was halved, from 10605 kg/ha to 5872 kg/ha.

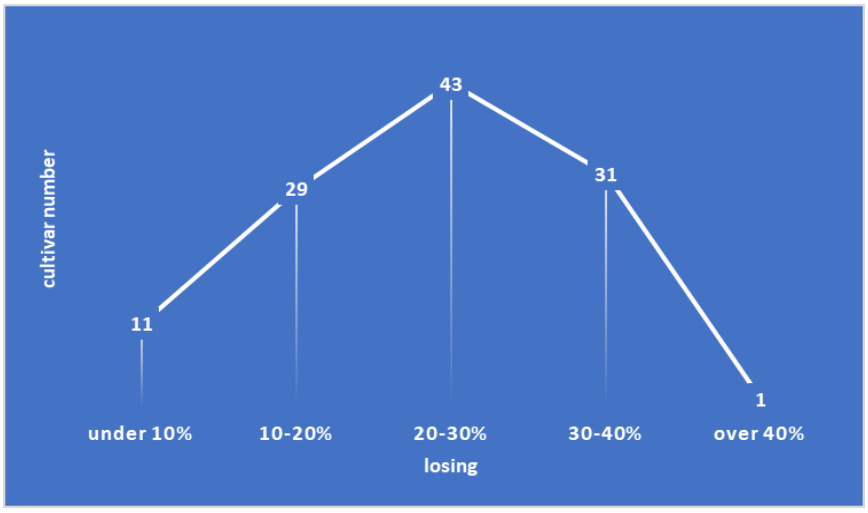

Figure 2. Distribution of varieties according to calculated losses between production in a favorable and unfavorable year

Applying the model of Triboi and Anne-Marie Triboi-Blondel (2008) who experimented with wheat under low and high temperature conditions and under different humidity conditions (irrigated and non-irrigated), the production, productivity elements and protein content were analyzed, under the natural conditions of the 5 years of experimentation at Caracal.
Without exception, for all the elements studied, decreases were highlighted in years with high temperatures regardless of the rainfall, but also in the year with low temperature and rainfall levels. This interaction and its influence on production and other elements studied are presented in Table 3.
An in-depth study on the production, hectoliter mass, protein content, days from 01.01. to earing and productivity elements (number of grains/ear, weight of grains/ear, mass of 1000 grains) in common wheat, regardless of variety, for the entire experimental period, is presented in Table 4.

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Table 3. Interaction temperatures x precipitation in the post-flowering period (May-June)

Temperature	**Low (sum of degrees = 30-36°C)**		**High (sum of degrees = 32-39°C)**	
Rainfall	Favorable (170 mm)	Drought (123 mm)	Favorable (159 mm)	Drought (59 mm)
Production (% of Control)	11459 (100)	8560 (75)	9543 (83)	7776 (68)
No. of grains/ear (% of Control)	41 (100)	38 (93)	38 (93)	42 (102)
TKW (% of Control)	43.8 (100)	39.1 (89)	39.1 (89)	28.3 (65)
Protein (% of Control)	12.3 (100)	10.5 (85)	11.0 (89)	11.8 (96)
Days from 01.01 to earing (% of Control)	132 (100)	130 (98)	135 (89)	126 (95)

*Experiment conducted in Caracal under natural climatic conditions on an assortment of 220 varieties tested during 2020-2024. The tested variants correspond to the following years: low temperature-favorable year (mt) = 2020; low temperature-dry year = 2023; high temperature-favorable year = 2021; high temperature-dry year = 2022
**Control used for percentage calculation: crop from favorable year and with low temperature

Table 4. Influence of water stress on yield and productivity elements under Caracal conditions

Characters	**Year with water stress-2022-**	**Years with moderate stress-2020,2024-**	**Stress-free year -2023-**	**Year with umidity stress-2021-**
Production	7678	9419	8599	9651
Hectoliter mass	65.4	78.0	71.3	70.1
No. of grains/ear	29	37	42	42
Grain weight/ear	1.53	1.74	1.88	1.70
Weight of 1000 grains	31.5	34.5	39.4	39.7
Protein (%)	10.9	11.1	12.0	11.3
Days from 01.01 to earing	127	136	133	135

Obviously, the year with water stress presented the lowest production, a hectoliter mass well below the take-up limit for baking, a low number of grains/ear and a similar grain weight/ear, a reduced 1000-grains weight, a low protein content and a shortened vegetation period due to the lack of precipitation amid high temperatures.

4. CONCLUSIONS

The variability of productions obtained on the chernozem of Caracal during the period 2020-2025 was extremely high. There were productions of approximately 4000 kg/ha but also of 12000 kg/ha.
On average in the five years of experimentation, the most productive variety was Anapurna with a production of 10180 kg/ha and the lowest production was recorded by Bezostaia – 5620 kg/ha.
There was no correlation between the average production of the varieties experimented throughout the period and the average Angot index, which suggests that there were other causes that reduced production, apart from climatic conditions, such as the strong attack of yellow rust in 2023.
The Glosa variety, the most cultivated variety in Romania, is in the group of varieties in which the loss of production between a favorable and an unfavorable year for the crop was below 10%, namely 3.3%. The variety with the highest loss was Tarascon with 44.6%. Its production was halved, from 10605 kg/ha to 5872 kg/ha.

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Without exception, for all the elements studied, decreases were highlighted in years with high temperatures regardless of the rainfall, but also in the year with low temperature and rainfall levels, after analyzing the results according to the model developed by Triboi in 2008. The year with water stress presented the lowest production, a hectoliter mass well below the takeover limit for baking, a small number of grains/ear and a similar grain weight/ear, a reduced 1000-grains weight, a low protein content and a shortened vegetation period due to the lack of rainfall amid high temperatures.

5. REFERENCES

Almansouri, M., Kinet, J.M., Lutts, S. (2001). Effect of salt and osmotic stresses on germination in durum wheat (Triticum durum Desf.). *Plant and Soil*, *231*(2), 243–254.

Anjum, S.A., Ashraf, U., Zohaib, A., Tanveer, M., Naeem, M., Ali, I., Tabassum, T., Nazir, U. (2017). Growth and developmental responses of crop plants under drought stress: A review. *Zemdirbyste-Agriculture*, *104*(3), 267–276.

Barnabas, B., Jager, K., Fehér, A. (2008). The effect of drought and heat stress on reproductive processes in cereals. *Plant, Cell & Environment*, *31*(1), 11-38.

Bhandari, R., Gnawali, S., Nyaupane, S., Kharel, S., Poudel, M., Panth, P. (2021). Effect of drought & irrigated environmental condition on yield & yield attributing characteristic of bread wheat-A review. *Reviews in Food and Agriculture*, *2*(2), 59–62.

Bonciu, E. (2019). The climate change mitigation through agricultural biotechnologies. *Annals of the University of Craiova-Agriculture, Montanology, Cadastre Series*, *49*(1), 36-43.

Dellal, I., Unuvar, F. (2019). Effect of climate change on food supply of Turkey. *J. Environ. Prot. Ecol*., *20* (2), 692-700.

Demirhan, A.A., Bayraktar, S.S. (2025). The impact of temperature and precipitation on wheat production in Türkiye. *Central Bank Review*, *25*(1), 100191.

Halbac-Cotoara-Zamfir, R., Halbac-Cotoara-Zamfir, C. (2021). A brief analysis of drought in western Romania based on SPI 3M evolution. *Actual Tasks on Agricultural Engineering*, *48*, 87-97.

Hajibarat, Z., Saidi, A. (2022). Senescence-associated proteins and nitrogen remobilization in grain filling under drought stress condition. *Journal of Genetic Engineering and Biotechnology*, *20*(1), 1-14.

Hossain, M.A., Wani, S.H., Bhattacharjee, S., Burritl, D.J., Tran, L.S.P. (2016). Drought stress tolerance in plants, vol 1: Physiology and biochemistry. *Journal of Physiology and Biochemistry*, *1*(1), 1-526.

Hussain, A., Jatoi, W.A. (2021). Drought tolerance indices of wheat (*Triticum aestivum* L.) genotypes under water deficit conditions. *Plant Cell Biotechnology and Molecular Biology*, *20*, 1-19.

Iordan, L.H. (2015). Drought in Romania. Effects and adaptive strategies. *Scientific Papers. Series A. Agronomy*, *LVIII*, 391-397.

Işlicaru, I., Roșculete, E., Bonciu, E., Petrescu, E. (2021). Research on the identification of high productivity winter wheat varieties and lines, tested on luvisol from Șimnic in the period 2004-2018, 2021. *Scientific Papers. Series A. Agronomy*, *LXIV*(1), 388-396.

Kou, X., Han, W., Kang, J. (2022). Responses of root system architecture to water stress at multiple levels: A meta-analysis of trials under controlled conditions. *Frontiers in Plant Science*, *13*, 1–16.

Lehari, K., Kumar, M., Burman, V., Vaishali, A., Kumar, V., Chand, P., Singh, R. (2019). Morphological, physiological and biochemical analysis of wheat genotypes under drought stress. *Journal of Pharmacognosy and Phytochemistry*, *SP2*, 1026–1030.

Ozdogan, M. (2011). Modeling the impacts of climate change on wheat yields in Northwestern Turkey. *Agric. Ecosyst. Environ*., *141*, 1-12.

Paunescu, R.A., Bonciu, E., Rosculete, E., Rosculete, C.A., Paunescu, G. (2024). Productivity and baking quality of autumn wheat varieties under different technological conditions on the Caracal chernozem. *Scientific Papers. Series A. Agronomy*, *LXVII*, Issue 1, 600-611.

Poudel, M. R., Ghimire, S., Pandey, M. P., Dhakal, K. H., Thapa, D. B. (2020). Evaluation of wheat genotypes under irrigated, heat stress and drought conditions. *Journal of Biology and Today's World*, *9*, 212.

Triboi, E., Triboi-Blondel, A.M. (2008). Qualité des récoltes et sécheresse. *Innovations Agronomiques*, *2*, 131-158

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Yue, Y., Zhang, P., Shang, Y. (2019). The potential global distribution and dynamics of wheat under multiple climate change scenarios. *Sci. Total Environ*., *688*, 1308–1318.

Zhai, S., Song, G., Qin, Y., Ye, X., Lee, J. (2017). Modeling the impacts of climate change and technical progress on the wheat yield in inland China: an autoregressive distributed lag approach. *PLoS One*, *12* (9), e0184474.

Zhang, H., Tang, Y., Chandio, A.A., Sargani, G.R., Ankrah Twumasi, M. (2022). Measuring the effects of climate change on wheat production: evidence from Northern China. *Int. J. Environ. Res. Publ. Health*, *19*, 12341.

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