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ADAPTATION OF PASTURE COMPOSITION TO CLIMATE CHANGE CONDITIONS – A FACTOR FOR INCREASING ANIMAL FODDER QUALITY AND IMPLIEDLY MILK PRODUCTION

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Abstract

Natural grasslands with spontaneous vegetation have been gradually replaced by new categories, where human intervention is considerable. Research has shown that their valorization is done through the application of modern technologies. Feed production and its cost are influenced and limited by climatic challenges, multiplying through the mirror effect, in human food. The aim of the work is to demonstrate, with the help of statistical indicators, the influence of temperatures and precipitation on feed and milk production. According to the calculations made, it emerged that extreme temperatures negatively influence the amount of feed obtained, with rapid evaporation taking place. The lack of precipitation increases the risk of severe drought, having a domino effect. This phenomenon leads to a reduction in the water level in rivers, the groundwater area, slows down crop growth, leads to increased pest attacks and favors the occurrence of fires. Adaptation to climate change is essential for mitigating potential damage and identifying opportunities for farmers to respond.

Key words: *climate change, pasture, fodder, temperature, precipitation*

INTRODUCTION

As agriculture developed, natural (primary) grasslands with spontaneous vegetation were replaced by new categories: permanent or secondary grasslands, temporary grasslands and intensive forage crops where human intervention is considerable. In most cases, grassland vegetation is made up of perennial plants, associated in complex groups that give them specific features, both in terms of the relationship between species and related to the environment (water regime and soil nutrients, temperature, grazing/mowing frequency).

However, the land area destined for animal feed is limited and even declining in Romania [8] and this a reason as farmers to look for alternatives on forage resources under the actual climate conditions [1].

Grassland plants belong to different botanical families with a wide spectrum of economic value. For example, there are valuable forage species with a good chemical composition and high yields, but also many less valuable species, consumed very little by animals because they can be toxic or harmful.

It follows that it is necessary to direct the process of vegetation formation on grasslands, in order to obtain plants with the best biological and economic characteristics.

Climate change has brought intense heat waves and heavy rainfall. Changing weather patterns require an adaptation of all livestock systems including the adaptation of pastures regarding the quality and quantity of fodder. Their effects vary depending on the region and the production systems [2].

Due to rising temperatures, the season may be extended, contributing to the growth of pastures especially in areas dependent on rainfall, and their instability may annihilate the benefits of a longer season [4].

Globally, climate change threatens the sustainability of ecosystem functioning. Generally, pastures in warmer areas are affected and can have a crucial impact on the production and nutritional traits (protein content, essential fatty acids, amino acids) of forage, but also from an economic point of view [6].

The adaptation of pastures to climatic conditions depends on the management of the

implementation of agricultural practices of grazing, which allows farmers to adapt to new challenges by including forage species that are favorable to climate change and can maintain their quality. Some studies have shown that the response of plants affects the quality and ruminal fermentation of forages, that is, the process by which plants are broken down in the rumen of animals to make them digestible [3].
A quantification of climate change on the livestock sector indicates that the impact is evident in the supply chain (production-consumption) with severe consequences in regions with warmer climates and socially and economically vulnerable [5].
According to the Report "Impact of Climate Change and Adaptation in the European Agricultural Sector", published in November 2024 by the European Environment Agency, a negative impact on agriculture is expected in many areas of Europe, especially in the south.
According to the press release issued by the Copernicus Climate Change Service (C3S), 2024 became the first year in which an annual temperature anomaly exceeding the threshold of 1.5 degrees Celsius above pre-industrial levels was recorded [10]. However, the environmental and climatic conditions in our country are still favorable for obtaining high yields of fodder crops [9].
The factors that determine their success are climatic, edaphic and the assortment of plants that make up the meadows. Meadows are successive forage crops and require a sum of temperature degrees of 1,200-2,000^{O}C during the vegetation period. This amount, from harvest to the first frost, determines the choice of varieties and hybrids. High temperatures negatively influence the amount of fodder obtained, due to the high evapo-transpiration of plants and pedological drought. The orientation towards obtaining quantitative and qualitative fodder, with constant production over time, is essential to maintain the price of finished products at an optimal level, without increases that would negatively affect the possibility of purchasing and consumption [11].
In extreme temperatures, rapid evaporation occurs, and if there is no precipitation, the risk of severe drought increases. Climate uncertainties make it difficult to predict the impacts of climate change, making the adaptation of livestock systems more complex [7].
The purpose of the paper is to study the influence of temperatures and precipitation on feed and milk production using regression equations, correlations and coefficient of determination.

MATERIALS AND METHODS

In this paper, the Pearson correlation coefficient was used to analyze the correlation between average annual temperatures and perennial forage production.
The second correlation analyzed was that between average annual precipitation and perennial forage production.
Based on statistical data from the INS, the correlations between average temperatures and average milk production, respectively between precipitation and average milk production, were analyzed during the period 2014-2023, at the national level.
The correlation and linear regression were calculated using the functions available in Excel.

RESULTS AND DISCUSSIONS

Analyzing the correlation between annual temperatures and perennial fodder production, we observe that up to a certain thermal threshold, this is favorable for the growth of fodder plants.

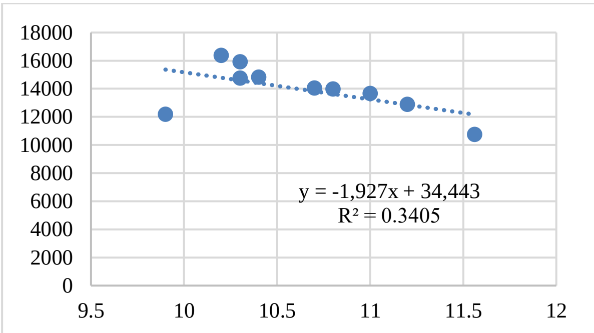

Fig. 1. Correlation between temperature and average perennial forage production, 2014-2023
Source: authors' calculations authors' calculations based on data from the National Institute of Statistics of Romania (NIS)

The increase in temperature above this threshold leads to a decrease in production yield.

The correlation coefficient of 0.58 indicates a good association between the two variables, and the coefficient of determination R^2 shows that 34.05% of the production value can be explained by the linear relationship with the recorded temperatures (Figure 1).

The correlation coefficient is positive and has a small value r = 0.583 indicating a moderate connection between the temperatures and forage production in the analyzed period. The coefficient of determination R^2 shows 34% of the variation in forage production is determined by the changes in the temperature regime.

Under these conditions, farmers can consider preventive measures and adaptation to the new conditions by irrigating fodder crops (Figure 1).

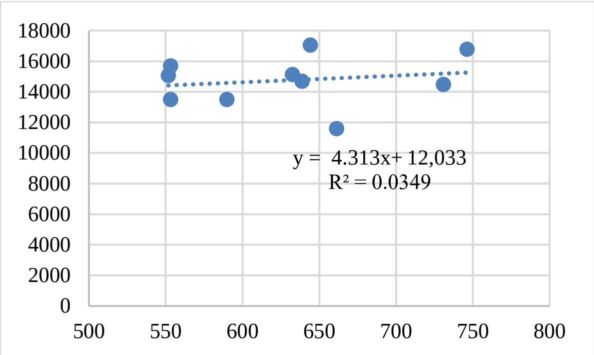

Fig. 2. Correlation between precipitations and average perennial forage production, 2014-2023
Source: authors' calculations based on data from the National Institute of Statistics of Romania (NIS)

Water also falls into the category of climatic factors. The minimum amount of precipitation required in a year is 125 mm annually.

The distribution over time intervals determines the minimum degree of soil moisture necessary for plant germination. Analyzing the correlation between annual precipitation and perennial forage production, we observe that up to a certain threshold they are favorable for the development of forage plants. An increase in precipitation above this threshold leads to a decrease in production yield.

The correlation coefficient of + 0.25 indicates an acceptable association between the two variables, and the coefficient of determination R^2 shows that 3.49% of the production value can be explained by the linear relationship with recorded precipitation (Figure 2).

The edaphic factors are the soil with its physical, chemical and biological properties. Good production is obtained on fertile, well-structured soils with a high capacity to retain water from precipitation.

Regarding the assortment of plants, successive crops are established according to the vegetation period and the requirements of the climate and soil. The first crop must leave the field as early as possible, and the second must be as drought-resistant as possible.

Since 2017, Nicolae Dragomir has been drawing attention to the fact that many of the organoleptic characteristics of animal products are directly influenced by the characteristics and quality of the feed consumed. A product of animal origin intensely influenced by the characteristics of the feed is milk, appreciated by consumers for its color, aroma, texture and flavor. The aroma, for example, is due to volatile substances present in the composition of dicotyledonous plants from the floristic structure of natural meadows (dandelion, yarrow, pennyroyal, wild carrot, plantain, mint). The flavor of this product is given by the sugar content, and the texture by the fat content. In other words, the diversity and abundance of meadows is felt in milk [2].

In practice, there are clear differences between milk from animals raised on natural grasslands and sown grasslands.

Milk from animals grazing on grasslands consisting only of grasses (sedge, ryegrass, fescue, etc.) is less fragrant, not having a specific aroma. This is due to the hexane present in these plants, which causes the oxidation of the milk.

Milk from animals grazing on grasslands with a high proportion of toxic floristic species has a “repulsive” aroma due to “plastic”, “metallic” or “pharmaceutical” odoriferous substances.

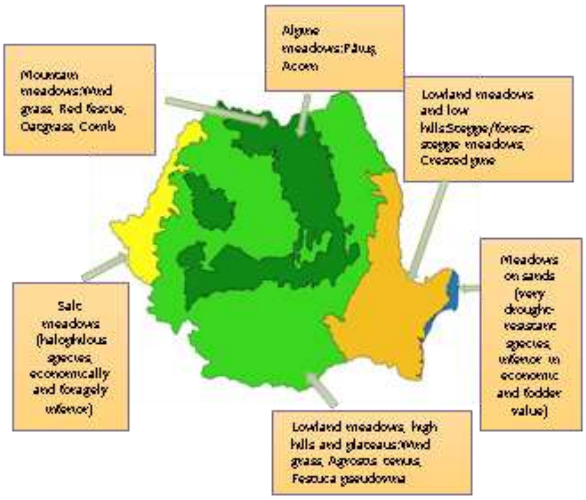

Fig. 3. Distribution of grasslands by geographical region
Source: authors' interpretation.

In contrast, milk from animals grazing on meadows in hilly and mountainous areas, made up of aromatic plants (thyme, rosemary, cumin, chicory, etc.), has a pleasant aroma due to "floral" type odoriferous substances. In the case of meadows made up of leguminous plants (white clover, red clover, alfalfa, vetch, etc.), the aroma of the milk is "grass", "hay" or "fruits", which gives it a special flavor [2].
Aromatic nuances are generally imperceptible in milk, being noticeable and making the difference between derivatives such as butter and cheese, as a result of the share of fatty acids that depend on the animal's diet.
The correlation coefficient determined between temperature and milk production is negative (-0.30%), indicating an acceptable association between the two variables. The correlation is negative and shows that, as temperatures increase, production tends to decrease, the relationship between the two variables being weakly consistent (Fig. 4).
The trend is negative and is given by the equation:

$$\mathbf{y = -1{,}043.6x + 58{,}076}$$

where the coefficient 1,043.6 shows that for every degree Celsius increase milk production decreases, and the intercept point 58,076 indicates the estimated production when the temperature is zero. The R^2 value represents the trend line of the data variations suggesting that only 9% of the variation in milk production can be explained by the variation in the average annual temperature. The remaining 91% is influenced by other factors, such as animal nutrition, health conditions, farm technologies, etc.

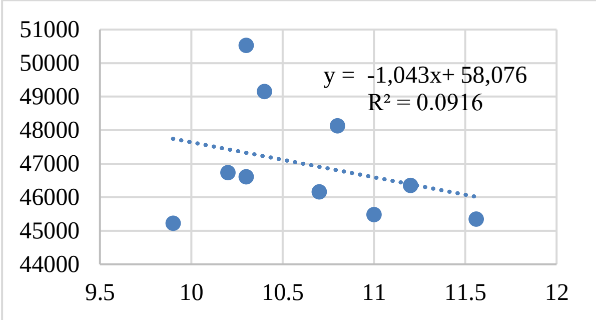

Fig. 4. Correlation between temperature and milk production, 2014-2023
Source: authors' calculations authors' calculations based on data from the National Institute of Statistics of Romania (NIS)

In the graphic representation it can be seen that in years with high temperatures the production is lower (e.g. 2023 with an average annual temperature of 11.56^0C, respectively 45,354 thousand hl of milk) and in years with moderate temperatures the production is higher (e.g. 2014 byh 10.3^0C and a production of 50,535 thousand hl) (Figure 4).

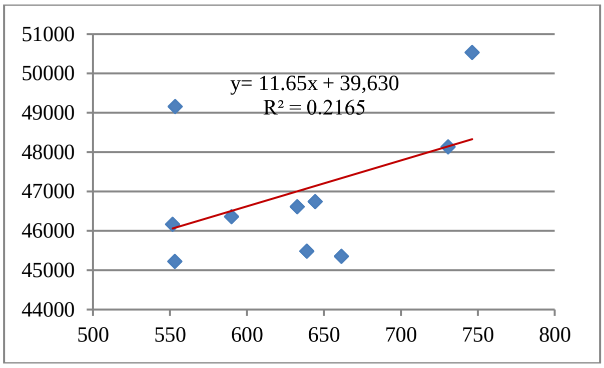

Fig. 5. Correlation between precipitation and milk production, 2014-2023
Source: authors' calculations based on data from the National Institute of Statistics of Romania (NIS)

A moderate positive relationship is given by the positive correlation coefficient r = 0.46 between milk production and precipitation in the analyzed period 2014-2023, which can be observed the significant influence of limiting climatic factors (Figure 5).
The quality of feed (nutritional value) is an essential factor in increasing milk production, depending on annual precipitation. So it can be

said that the relationship between the two variables is deterministic in the trend of increasing milk production.

Dairy products from large and small ruminants are rich in saturated fatty acids. Excessive consumption of such products increases the risk of cardiovascular diseases in humans. To prevent these risks, people intervene in the diet of animals by giving them green fodder, rich in Omega-3 (ryegrass, white clover, etc.) harvested in spring or early autumn. The content of fatty acids, Omega-3 in particular, is higher in hilly and mountain meadows than in plains.

Correct and balanced nutrition of animals determines the production of quality milk and derivatives, directly influencing human health. The increase in the content of Omega-3 and Omega-6 in feed is correlated with the increase in animal production. The quality of feed is assessed by the Omega-6/Omega-3 ratio which must be 4-5/1 (Table 1).

Table 1. Feed quality depending on the ratio of saturated fatty acids

Feed	Omega-3	Omega-6	Omega-6/ 0mega-3 ratio
Seeding pasture	1.60	0.30	0.19
White clover	1.52	0.53	0.35
Ryegrass	1.48	0.28	0.19
Natural pasture	1.36	0.42	0.31
Red clover	0.94	0.46	0.48
Dactylis glomerata	0.82	0.24	0.29
Lucerne	0.73	0.38	0.52

Source: taken from Dragomir N., Ferma Ferma Magazine no. 2 (185) from February 1-15, 2017 [2].

The lower content of Omega-6 than Omega-3 is beneficial for animal health. Excess Omega-6 can lead to severe inflammation in animals that consume poor quality feed. The optimal balance of fatty acids with a significant ratio is represented by sown meadow and ryegrass (0.9; 0.29), and the highest ratios may be less beneficial (high Omega-6 content) is represented by alfalfa and red clover (0.52; 0.48).

CONCLUSIONS

It is necessary to identify the moment of occurrence of extreme phenomena, based on early warning systems regarding the occurrence of heat waves or cold waves, the occurrence of floods or the occurrence of drought, as well as knowledge of the effects they have on crops.

Knowledge of meteorological phenomena must be based on technological practices applied in relation to the current evolution of climatic conditions and predictable scenarios.

Adaptation to the effects of climate change is a complex process based on optimizing the duration of the vegetation period of agricultural crops, on the resistance of genotypes to extreme temperatures, to deficits/excesses of water in the soil and to the increased risk of the appearance of phytopathogenic agents, on ecological plasticity, on tolerance to the effects of extreme weather phenomena.

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REFERENCES

[1]Chetroiu, R., Ilie, D.M, 2024, Challenges and alternatives on the forages resources providing under current environmental and climate conditions, Scientific Papers Series "Management, Economic Engineering in Agriculture and Rural Development, Vol.24(2), 267-272.

[2]Dragomir, N., 2017, The quality of green fodder and human health, Ferma Magazine no.2 (185), https://revista-ferma.ro/calitatea-furajelor-verzi-si-sanatatea-omului/, Accessed on January 15, 2025

[3]Hart, H.E., Christofides, S.R., Davies, T.E., Steven, P.R., Creevey, J.C., Müller, T.C., Rogers, J. H., Kingston-Smith, A., 2022, Forage grass growth under future climate change scenarios affects fermentation and ruminant efficiency, October 2022, Scientific Reports. 12(1), 4454. doi: 10.1038/s41598-022-08309-7.

[4]Izaurralde, R., Thomson, A., Morgan, J., Fay, P., Polley, H., Hatfield, J., 2011, Climate Impacts on Agriculture: Implications for Forage and Rangeland Production. Agronomy Journal, 103 (2), 371-381.

[5]Joyce, L., Briske, D., Brown, J., Polley, H., McCarl, B., Bailey, D., 2013, Climate Change and North American Rangelands: Assessment of Mitigation and

Adaptation Strategies. Rangeland Ecology & Management**,** 66 (5), 512-528.

[6]Martins-Noguerol, R., Moreno-Pérez, A.J., Pedroche, J., Gallego-Tévar, B., Cambrollé, J., Matías, L., Fernández-Rebollo, P., Martínez-Force, E., Pérez-Ramos, I.M., Climate change alters pasture productivity and quality: Impact on fatty acids and amino acids in Mediterranean silvopastoral ecosystems, Agriculture, Ecosystems & Environment, Vol. 358, 1 December 2023, 108703.

[7]Plesa, A., Pacurar, F., Rotar, I., Ghete, I., 2024, Fodder crops and climate change, Romanian Journal of Grassland and Forage Crops (2024) 30, 37-42.

[8]Popescu, A., Tindeche, C., Marcuta, A., Marcuta, L., Hontus, A., Stanciu, M., 2024, Land use for animal feed in Romania in the period 2013-2022. Scientific Papers. Series "Management, Economic Engineering in Agriculture and rural development", Vol. 24(2), 799-808.

[9]Puia, I., Pavel, C., Bărbulescu, C., Oprin, C., 1980, Production and storage of fodder, Didactic and Pedagogical Publishing House.

[10]Tarnavsky, E., Rossi, M., Bussay, A., Morel, J., Biavetti, I., Bratu, M., Cerrani, I., Claverie, M., De Palma, P., Fumagalli, D., Manfron, G., Niemeyer, S., Nisini Scacchiafichi, L., Panarello, L., Seguini, L., Van Den Berg, M. and Zucchini, A., 2024. JRC MARS Bulletin - Crop monitoring in Europe - January 2024 Vol. 32 No 1, Van Den Berg, M. editor(s), Publications Office of the European Union, Luxembourg, 2024, doi:10.2760/03283, JRC136584.

[11]Tulu, D., Gadissa, S., Hundessa, F., Kebede, E., 2023, Contribution of Climate-Smart Forage and Fodder Production for Sustainable Livestock Production and Environment: Lessons and Challenges from Ethiopia, Hindawi, Advances in Agriculture, Vol. 2023, Article ID 8067776, pp. 1-11., https://doi.org/10.1155/2023/8067776