# VEGETATION CONDITIONS OF AGRICULTURAL CROPS IN THE BIHARIEI PLAIN

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**Abstract**

*The research was conducted over a period of four years (2019–2023) with the aim of identifying and mapping the soil taxonomic units in the Bihariei Plain, quantifying existing trophic conditions, cataloguing limiting and restrictive factors of agricultural production, and establishing the main directions for intervention. In order to identify and determine the existing soil taxonomic units, assess their spatial distribution, and map them, a total of 80 primary soil profiles, 160 secondary profiles, and 250 control profiles were investigated in the field. To determine the chemical parameters of the soils, 320 soil samples were collected and analyzed. The analysis of soil chemical parameters was carried out using spectrophotometry. The study also focused on and quantified: the temporal variation of climatic parameters (air temperature, soil temperature, precipitation, relative air humidity, and air current movements) and the soil trophic conditions (nutrient content, current acidity – pH value, excess moisture from precipitation, and excess groundwater). Based on the research results, the limiting and restrictive factors of agricultural production were identified, and the main intervention strategies were outlined to ensure optimal trophic conditions for the growth, development, and productivity of agricultural crops: water conservation measures in soil and strategies to enhance the soil's fertility potential. The results of this research can be stored in databases, which may be accessed and utilized in agricultural practice by economic units operating in the agricultural sector.*

**Keywords:** trophic conditions; climatic regime; soil types; fertility; limiting factor
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## INTRODUCTION

The Bihariei Plain is located in the northwestern part of Romania (**Figure 1**) and, from a geographical standpoint, represents a subdivision of the Crişurilor Plain (3). Within the geographical expanse of the Crişurilor Plain, it occupies a northeastern position (**Figure 2**), being bordered by the following units: to the north – the Barcăului Plain, northwest – the Ierului Plain, west – the Parhida Plain, southwest – the Borş Plain, south – the Bihariei Plain and the Oradea Hills, southeast – the Oradea Hills, and to the east – the Barcău Corridor (4, 5, 12). (**Figure 3**).

From an administrative - territorial perspective, the Bihariei Plain is situated in the northern part of Bihor County. The Bihariei Plain covers a total area of 10,354.2 hectares and is located within the boundaries of the following localities: Roşiori, Vaida, Tămăşeu, Satu Nou, Hodoş, Sălard, Biharia, and Cauaceu. **Figure 1** shows the geographical location of the Bihariei Plain.


**Figure 1**. The Bihariei Plain. Geographical location.

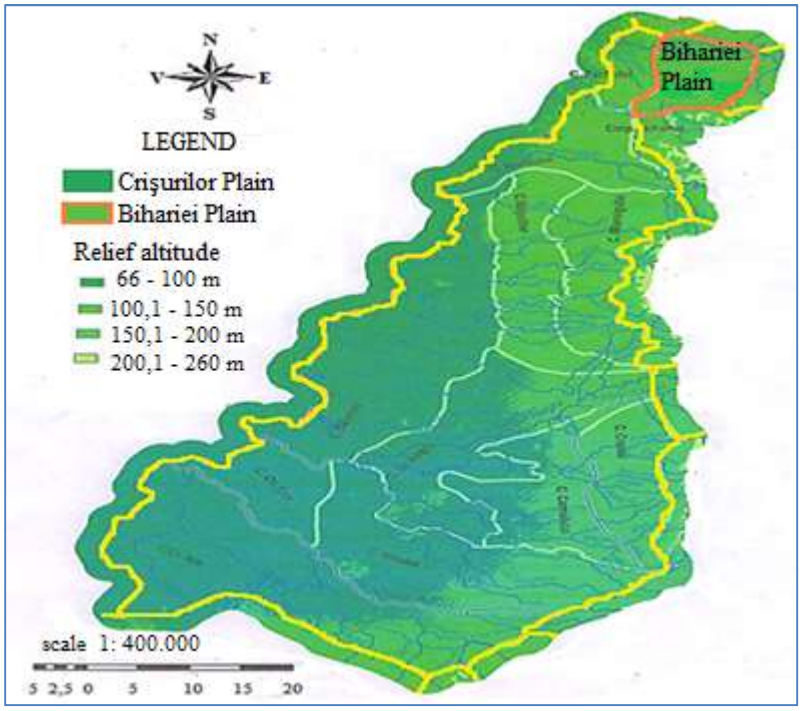


**Figure 2**. The Bihariei Plain, a subunit of the Crişurilor Plain (Source: adapted from G. Posea).


**Figure 3.** The Bihariei Plain. Boundaries and neighboring units

In the Bihariei Plain region, soils have formed and evolved on surface deposits of various origins, including deluvial, proluvial, and deluvial-proluvial deposits (gravels and sands, loess-like deposits, clays, and marly clays). Groundwater is found at critical and subcritical depths (1.5–2 meters deep) in the lower sectors of the Biharia Plain, particularly in the areas surrounding the localities of Mihai Bravu, Roşiori, Tămăşeu, Satu Nou, Cauaceu, and Hodoş. These areas are characterized by the presence of Gleysol soil types and gleic, endogleic, and batigleic subtypes of other soil types (12). The groundwater in the region exhibits low levels of chloridic and sulphatic mineralization, with less than 3 g/L of soluble salts. From a morphometric perspective, the Biharia Plain has elevations ranging from 100 to 260 meters. In the southern and southeastern parts, the elevation reaches up to 260 meters, gradually decreasing along the S–N and E–W alignments.

## MATERIALS AND METHODS

The study was conducted over a four-year period: 2021–2024. Climatic parameters were analyzed and interpreted based on meteorological data provided by the National Meteorological Administration of Romania, Oradea Meteorological Station (2, 9, 10). The following climatic parameters were included in the study: air temperature, soil temperature, precipitation, relative air humidity, and air current movements (17). The research, identification, spatial delineation, and mapping of soil taxonomic units were carried out through the investigation of 80 primary soil profiles, 160 secondary profiles, and 250 control profiles. Soil taxonomic units were identified at the level of class, type, and subtype according to the Romanian System of Soil Taxonomy 2012+ (SRTS-2012+) (7), and subsequently translated into the World Reference Base for Soil Resources (WRB-SR-1998) (8). To determine the fertility potential of the soils, a total of 380 soil samples were collected at two depths: 0–15 cm and 15–30 cm. The analyses focused on current acidity (pH), total nitrogen, available phosphorus, and available potassium (11). The analytical methods for agrochemical indicators, as well as the data processing and interpretation, were conducted in accordance with the standards and methodology developed by the National Research and Development Institute for Soil Science, Agrochemistry, and Environmental Protection (ICPA) Bucharest (6).

## RESULTS AND DISCUSSION

### 1. Climatic Regime of the Biharia Plain

The Bihariei Plain area falls within the Cf climatic province, specifically the Cfbx climatic subprovince. The Martonne aridity index in this region ranges between 45 and 50. The monitoring and analysis of climatic parameters were carried out based on climatological data provided by the National Meteorological Administration (ANM) in Bucharest. Due to its geographical position, the Biharia Plain exhibits noticeable climatological variations. The northern and northwestern sectors of the plain are influenced by climatic parameters monitored by the Săcueni Meteorological Station, while the remaining area is covered by data from the Oradea Meteorological Station (**Figure 4**). The following climatic parameters were monitored and quantified: air temperature, precipitation, relative air humidity, as well as the direction, frequency, and speed of air currents. The study was conducted over a four-year period: 2021, 2022, 2023, and 2024.

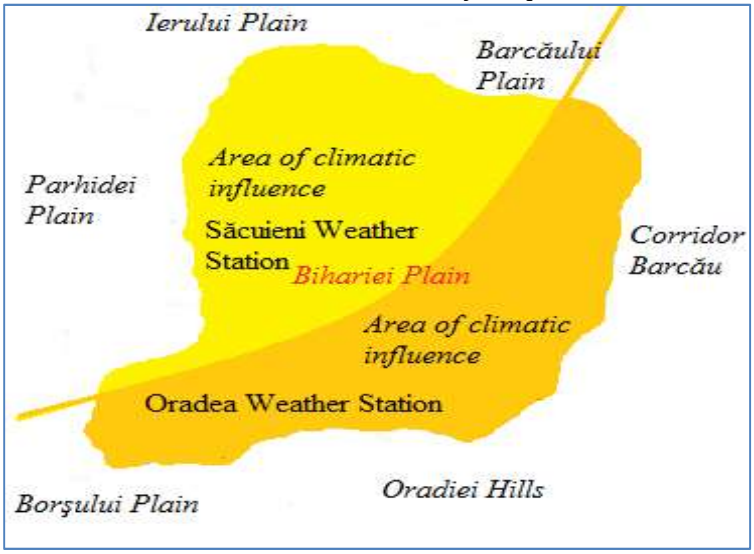


**Figure 4**. Climatic influence zones in the Bihariei Plain

#### 1.1. Air Temperature

The values of the climatic indicator *air temperature* were processed based on meteorological data provided by the Săcueni and Oradea Meteorological Stations.

*Săcueni Meteorological Station*

The multiannual average air temperature for the period 2021–2024 was +12.5 °C, with recorded maximum values of +39.4 °C (23.07.2022) and minimum values of −15.2 °C (13.01.2022).

*Oradea Meteorological Station*

The multiannual average air temperature for the period 2021–2024 was +12.8 °C, with recorded maximum values of +39.0 °C (13.07.2024) and minimum values of −15.0 °C (12.01.2022). The annual average temperatures during the 2021–2024 period ranged from +11.4 °C (2021 – Săcueni Station) to +13.9 °C (2024 – Oradea Station). On a yearly basis, the lowest values were recorded in 2021 (+11.4 °C – Săcueni Station; +11.6 °C – Oradea Station), while the highest were observed in 2024 (+13.3 °C – Săcueni Station; +13.9 °C – Oradea Station). The annual average air temperature values for the research period 2021–2024 are presented in **Table 1**. The monthly average temperature values for the period 2021–2024 are presented in **Table 2**.

**Table 1.** Annual average air temperatures for the period 2021–2024. (Data provided by the National Meteorological Administration – Săcueni and Oradea Meteorological Stations).

| Period | Average annual temperatures - °C | |
|---|---|---|
| | Săcueni Weather Station | Oradea Weather Station |
| 2021 | +11.4 | +11,6 |
| 2022 | +12.2 | +12,3 |
| 2023 | +13.0 | +13.2 |
| 2024 | +13.3 | +13.9 |

**Table 2.** Monthly average temperature values for the period 2021–2024**.** (Data provided by the National Meteorological Administration – Săcueni and Oradea Meteorological Stations).

| Luna | Temperatura medie lunară - °C - 2021 - 2024 | |
|---|---|---|
| | Staţia Meteorologică Săcuieni | Staţia Meteorologică Oradea |
| Ianuarie | +2.0 | +2.2 |
| Februarie | +4.7 | +4.7 |
| Martie | +7.1 | +7.0 |
| Aprilie | +10.6 | +10.4 |
| Mai | +16.7 | +16.6 |
| Iunie | +21.6 | +21.9 |
| Iulie | +24.0 | +24.5 |
| August | +23.2 | +23.8 |
| Septembrie | +18.1 | +18.5 |
| Octombrie | +12.5 | +12.8 |
| Noiembrie | +5.7 | +6.2 |
| Decembrie | +2.8 | +3.1 |

Following the analysis of the monthly average temperature values, no significant differences were observed in the variation of this indicator within the studied area. The monthly average temperatures, by research year, recorded the lowest values in January 2022 (−0.5 °C at both Săcueni and Oradea Meteorological Stations), and the highest values in July 2024 (+24.7 °C at Săcueni Meteorological Station and +25.7 °C at Oradea Meteorological Station). The monthly average temperature values by research year for the period 2021–2024 are presented in **Table 3**. In **Figures 5** and **6**, the monthly average temperatures by research year for the period 2021–2024 are graphically presented for the Săcueni Meteorological Station and the Oradea Meteorological Station, respectively.

**Table 3.** Monthly average temperature values by research year for the period 2021–2024. (Data provided by the National Meteorological Administration – Săcueni and Oradea Meteorological Stations).

| Month | Monthly average temperature | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 2021 | | 2022 | | 2023 | | 2024 | |
| | Săcuieni | Oradea | Săcuieni | Oradea | Săcuieni | Oradea | Săcuieni | Oradea |
| I | +1.8 | +1.8 | -0.5 | -0.5 | 5.1 | +5.3 | 1.8 | +2.2 |
| II | +3.2 | +3.7 | +4.5 | +4.4 | 2.6 | +2.3 | 8.7 | +8.5 |
| III | +5.4 | +5.0 | +5.3 | +5.3 | 7.8 | +7.7 | 10.2 | +10.2 |
| IV | +9.2 | +8.8 | +9.7 | +9.7 | 9.8 | +9.6 | 14.2 | +14.1 |
| V | +15.0 | +14.6 | +17.5 | +17.2 | 16.7 | +16.8 | 17.8 | +17.9 |
| VI | +22.0 | +22.0 | +22.7 | +22.9 | 20.0 | +20.1 | 21.9 | +22.5 |
| VII | +24.3 | +24.9 | +23.8 | +24.0 | 23.3 | +23.5 | 24.7 | +25.7 |
| VIII | +21.2 | +21.8 | +23.8 | +24.2 | 23.3 | +23.6 | 24.5 | +25.7 |
| IX | +16.6 | +17.3 | +16.0 | +16.1 | 20.8 | +21.2 | 19.0 | +19.6 |
| X | +10.4 | +11.0 | +12.7 | +12.9 | 15.2 | +15.4 | 11.7 | +12.0 |
| XI | +6.0 | +6.5 | +7.0 | +7.6 | 6.5 | +6.9 | 3.5 | +4.1 |
| XII | +1.6 | +2.0 | +3.7 | +4.0 | 3.7 | +4.1 | 2.2 | +2.2 |

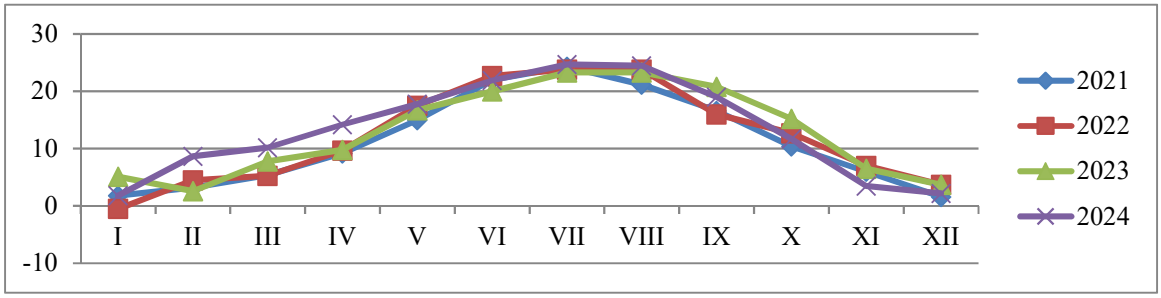


**Figure 5**. Graphical representation of monthly average temperatures by research year for the period 2021–2024. Săcueni Meteorological Station.

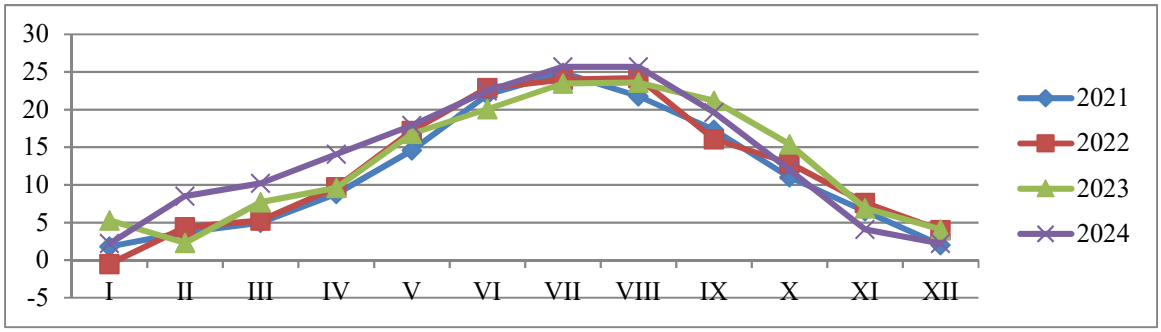


**Figure 6**. Graphical representation of monthly average temperatures by research year for the period 2021–2024. Oradea Meteorological Station.

### 1.2. Precipitation

The multiannual average precipitation for the research period 2021–2024 was 571.25 mm at the Săcueni Meteorological Station and 723 mm at the Oradea Meteorological Station. A humidity difference of 151.75 mm was recorded between the northern and northwestern parts of the Biharia Plain and its southern and eastern parts. Annual precipitation registered the lowest values in 2024 (477 mm at Săcueni Meteorological Station, 571 mm at Oradea Meteorological Station) and the highest values in 2023 (674

mm at Săcueni Meteorological Station, 903 mm at Oradea Meteorological Station). Annual precipitation recorded during the study period 2020–2023 are presented in **Table 4**.

**Table 4.** Annual precipitation recorded during the period 2020–2023. (Data provided by the National Meteorological Administration – Săcueni and Oradea Meteorological Stations).

| Period | Annual recorded precipitation - mm | |
|---|---|---|
| | Săcueni Weather Station | Oradea Weather Station |
| 2021 | 609 | 667 |
| 2022 | 525 | 752 |
| 2023 | 674 | 903 |
| 2024 | 477 | 571 |

The average monthly precipitation for the research period 2021–2024 recorded the lowest values during the months of March and October, and the highest values during September and November (minimum recorded: 19.75 mm in October at the Săcueni Meteorological Station; maximum recorded: 110.5 mm in September at the Oradea Meteorological Station). Average monthly precipitation values for the research period 2021–2024 are presented in **Table 5**. Monthly precipitation by research year, recorded during the period 2021–2024, are presented in **Table 6**.

**Figures 7** and **8** graphically present the monthly precipitation by research year, recorded during the period 2021–2024, for the Săcueni Meteorological Station and the Oradea Meteorological Station, respectively.

**Table 5.** Average monthly precipitation for the research period 2021–2024. (Data provided by the National Meteorological Administration – Săcueni and Oradea Meteorological Stations).

| Month | Monthly average precipitation - mm - 2021 - 2024 | |
|---|---|---|
| | Săcueni Weather Station | Oradea Weather Station |
| I | 45.5 | 57.25 |
| II | 27.25 | 37.5 |
| III | 19.75 | 22.5 |
| IV | 47 | 45.75 |
| V | 43 | 54 |
| VI | 53.25 | 57.56 |
| VII | 72 | 67.75 |
| VIII | 41.51 | 43.34 |
| IX | 64.25 | 110.5 |
| X | 19.75 | 20.25 |
| XI | 70.25 | 102.75 |
| XII | 67.5 | 78.5 |

**Table 6.** Monthly precipitation by research year recorded during the period 2021–2024. (Data provided by the National Meteorological Administration – Săcueni and Oradea Meteorological Stations).

| Month | Monthly average precipitation - mm - 2021 - 2024 | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Săcuieni Weather Station | | | | Oradea Weather Station | | | |
| | 2021 | 2022 | 2023 | 2024 | 2021 | 2022 | 2023 | 2024 |
| I | 67 | 22 | 50 | 42 | 86 | 24 | 68 | 51 |
| II | 58 | 16 | 27 | 7.5 | 76 | 31 | 36 | 7.1 |
| III | 29 | 5.0 | 28 | 18 | 28 | 19 | 42 | 29 |
| IV | 43 | 65 | 36 | 45 | 51 | 79 | 54 | 58 |
| V | 67 | 14 | 60 | 32 | 117 | 36 | 63 | 18 |
| VI | 7.5 | 39 | 55 | 113 | 6.2 | 40 | 65 | 119 |
| VII | 127 | 45 | 80 | 37 | 47 | 104 | 96 | 25 |
| VIII | 40 | 41 | 62 | 22 | 37 | 29 | 88 | 18 |
| IX | 27 | 137 | 30 | 64 | 12 | 213 | 79 | 139 |
| X | 12 | 6.6 | 36 | 24 | 5.6 | 6 | 44 | 26 |
| XI | 55 | 66 | 104 | 56 | 122 | 79 | 140 | 70 |
| XII | 76 | 71 | 105 | 17 | 79 | 93 | 129 | 13 |

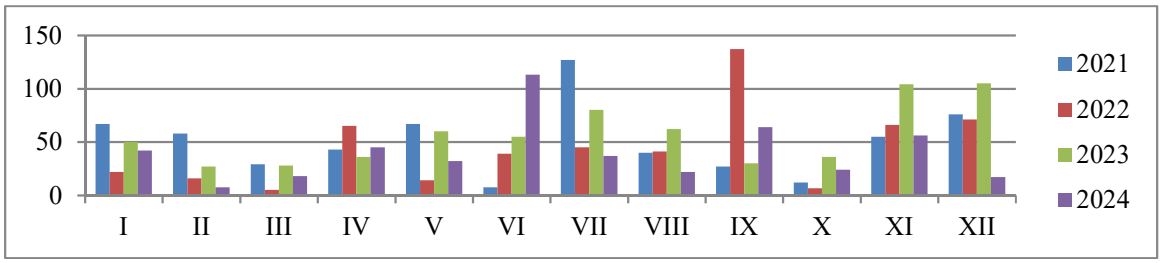


**Figure 7**. Graphical representation of monthly precipitation by research year recorded during the period 2021–2024 for the Săcueni Meteorological Station.

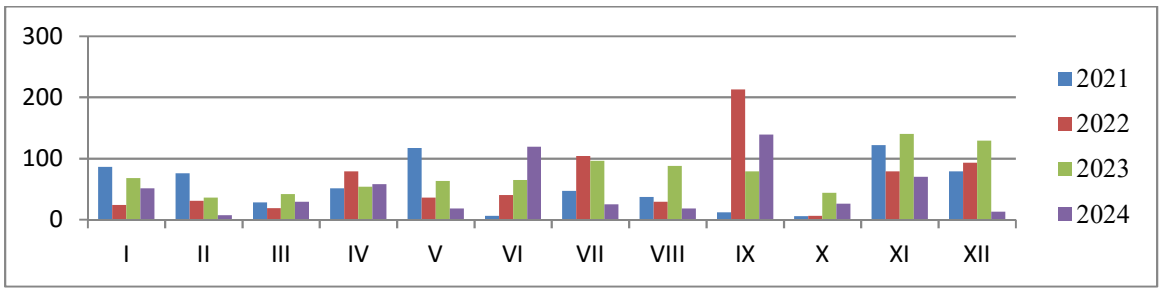


**Figure 8**. Graphical representation of monthly precipitation by research year recorded during the period 2021–2024 for the Oradea Meteorological Station.

### 1.3. Relative Air Humidity

The average relative air humidity for the entire research period 2021–2024 was 72% at both stations. Monthly relative air humidity showed the lowest values in July (61% at the Săcueni Meteorological Station, 58% at the Oradea Meteorological Station)

and the highest values in December (88% at both meteorological stations). **Table 7** presents the monthly relative air humidity expressed as a percentage, measured at 2 meters above the ground, for the period 2021–2024

**Table 7.** Monthly relative air humidity expressed as a percentage, measured at 2 meters above ground, for the period 2021–2024. (Data provided by the National Meteorological Administration – Săcueni and Oradea Meteorological Stations).

| Luna | Săcuieni Weather Station | Oradea Weather Station |
|---|---|---|
| | Average value - % - 2021-2024 | Average value - % - 2021-2024 |
| I | 83 | 85 |
| II | 76 | 78 |
| III | 61 | 64 |
| IV | 67 | 69 |
| V | 66 | 68 |
| VI | 65 | 64 |
| VII | 61 | 58 |
| VIII | 64 | 60 |
| IX | 69 | 68 |
| X | 73 | 74 |
| XI | 86 | 86 |
| XII | 88 | 88 |

Monthly relative air humidity by research year showed the lowest values during the period from June to September and the highest values between November and February. **Table 8** presents the monthly relative air humidity values by research year for the period 2021–2024.

**Figures 9** and **10** graphically present the monthly relative air humidity values, expressed as a percentage at 2 meters above ground level, by research year for the period 2021–2024, for the Săcueni Meteorological Station and the Oradea Meteorological Station, respectively.

**Table 8.** Monthly relative air humidity values by research year for the period 2021–2024. (Data provided by the National Meteorological Administration – Săcueni and Oradea Meteorological Stations).

| Month | Săcuieni Weather Station | | | | Oradea Weather Station | | | |
|---|---|---|---|---|---|---|---|---|
| | Average value - % - 2021 | Average value - % - 2022 | Average value - %-2023 | Average value - % - 2024 | Average value - % - 2021 | Average value - % - 2022 | Average value - % - 2023 | Average value - % - 2024 |
| I | 85 | 82 | 87 | 80 | 85 | 83 | 85 | 83 |
| II | 83 | 72 | 77 | 71 | 81 | 74 | 79 | 73 |
| III | 62 | 48 | 67 | 67 | 64 | 51 | 70 | 67 |
| IV | 67 | 67 | 70 | 64 | 69 | 68 | 72 | 64 |
| V | 69 | 60 | 70 | 65 | 72 | 63 | 70 | 66 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| VI | 59 | 56 | 72 | 73 | 60 | 55 | 70 | 68 |
| VII | 66 | 50 | 66 | 63 | 61 | 50 | 64 | 55 |
| VIII | 67 | 61 | 68 | 60 | 62 | 59 | 65 | 53 |
| IX | 69 | 78 | 65 | 64 | 64 | 78 | 63 | 61 |
| X | 68 | 81 | 66 | 79 | 66 | 80 | 66 | 78 |
| XI | 85 | 91 | 83 | 85 | 84 | 89 | 83 | 83 |
| XII | 87 | 88 | 83 | 89 | 88 | 87 | 85 | 89 |

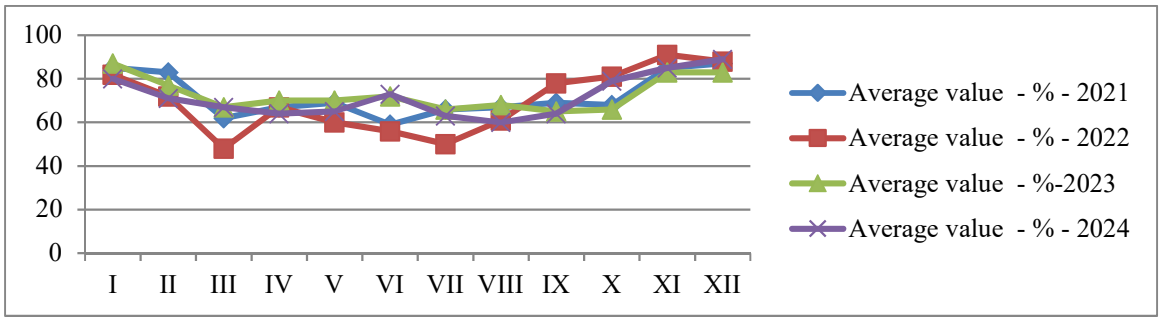


**Figure 9**. Graphical representation of monthly relative air humidity values, expressed as a percentage at 2 meters above ground, by research year for the period 2021–2024 for the Săcueni Meteorological Station.

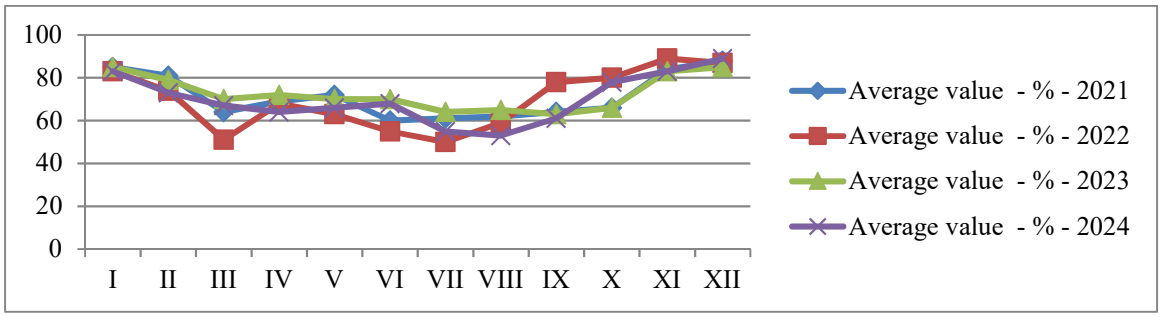


**Figure 10**. Graphical representation of monthly relative air humidity values, expressed as a percentage at 2 meters above ground, by research year for the period 2021–2024 for the Oradea Meteorological Station.

### 1.4. Direction and Frequency of Air Currents

For the entire research period 2021–2024, the average wind speed recorded was 3.2 m/s, with a maximum speed of 14 m/s. The currents with the highest frequency were from the NE (10.7%) and SW (18.5%) directions at the Săcueni Meteorological Station, and from the N (9.4%), E (19.4%), and S (14.6%) directions at the Oradea Meteorological Station. **Table 9** presents the cardinal directions of the air currents and their frequencies for the entire study period 2021–2024 (data provided by ANM – Săcueni Meteorological Station and Oradea Meteorological Station). In **Figure 11**, the cardinal direction of air currents and their frequency for the entire study period 2021–2024 are graphically presented.

**Table 9**. Cardinal directions of air currents and their frequencies for the entire study period 2021–2024 (data provided by ANM – Oradea Meteorological Station).

| Period | | Cardinal direction of air currents and frequency | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 2021 - 2024 | Săcuieni Weather Station | N | NNE | NE | ENE | E | ESE | SE | SSE |
| | | 5.4 % | 6.0 % | 10.7 % | 7.7 % | 6.0 % | 4.2 % | 3.0 % | 2.9 % |
| | | S | SSW | SW | WSW | W | WNW | NW | NNW |
| | | 6.9 % | 8.8 % | 18.5 % | 10.5 % | 4.9 % | 1.3 % | 1.4 % | 1.6 % |
| | Oradea Weather Station | N | NNE | NE | ENE | E | ESE | SE | SSE |
| | | 9.4 % | 6.9 % | 3.4 % | 3.4 % | 19.4 % | 6.6 % | 3.7 % | 4.2 % |
| | | S | SSW | SW | WSW | W | WNW | NW | NNW |
| | | 14.6 % | 6.9 % | 4.3 % | 3.1 % | 4.1 % | 2.6 % | 3.0 % | 4.5 % |

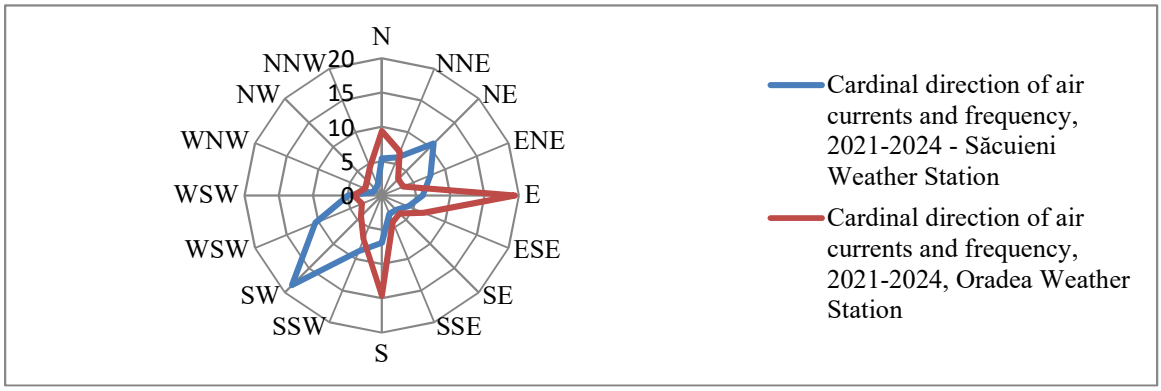


**Figure 11**. Cardinal direction of air currents and their frequency for the entire study period 2021–2024.

## 2. Higher - level soil taxonomic units in the Bihariei Plain

Following pedological mapping activities, five main soil types were identified in the Bihariei Plain area: Fluvisols, Phaeozems, Eutric Cambisols, Luvisols, and Gleysols. The Bihar Plain covers a total area of 10,354.2 hectares and is located within the territories of the following localities: Roşiori, Vaida, Tămăşeu, Satu Nou, Hodoş, Sălard, Biharia, Cauaceu. **Table 10** presents the soil units of the Bihar Plain area by administrative-territorial units (according to WRB-SR-1998).

**Table 10**. Soil units in the Bihariei Plain area (according to WRB-SR-1998) by administrative-territorial units and surface areas.

| Tipul de sol | Aria de răspândire | Supface - Ha |
|---|---|---|
| Fluvisols | Cauaceu, Sălard, Biharia | 108,4 |
| Phaeozems | Satu Nou, Biharia, Sălard, Tămăşeu, Roşiori | 2552,7 |
| Eutric cambisols | Tămăşeu, Vaida, Sântimbreu, Sălard, Hodoş, Roşiori | 3452,8 |
| Luvisols | Biharia, Cauaceu, Sălard | 3300 |
| Gleysols | Roşiori, Tămăşeu, Satu Nou, Biharia Cauaceu | 726,2 |
| Lakes, canals, streams | | 214,1 |
| TOTAL SURFACE | | 10 354, 2 |

The largest soil areas are occupied by the Eutric Cambisols type, covering 3,452.8 ha; followed by Luvisols with 3,300 ha; Phaeozems with 2,552.7 ha; Gleysols with 726.2 ha; and Fluvisols with 108.4 ha. **Figure 12** presents the Soil map of the Bihariei Plain area.

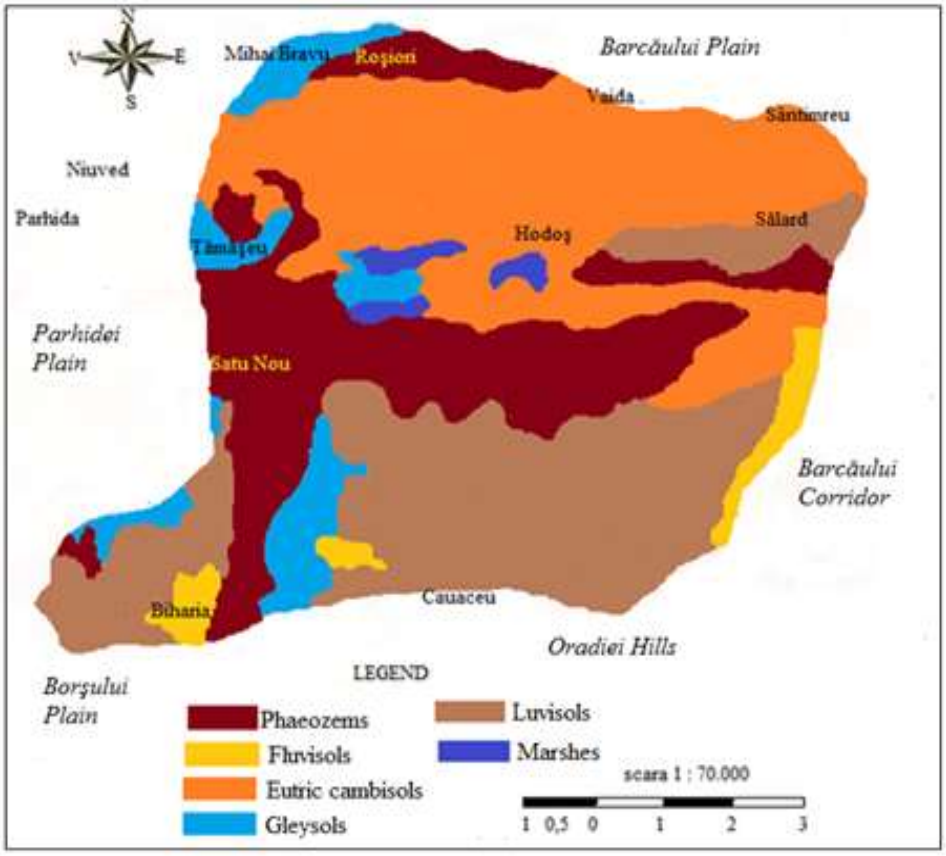


**Figure 12**. Soil map of the Bihariei Plain area (WRB-SR-1998).

**3. Limiting Factors of Agricultural Production in the Bihar Plain**

The main limiting factors for agricultural production in the Bihariei Plain are represented by the climatic regime (air temperature, precipitation, atmospheric humidity, direction and speed of air currents), excess groundwater moisture, current soil acidity, and low nutrient element content (14, 15, 17)

**3.1. Air Temperature**

In agricultural practice, particular importance is given to the temperature regime during the bioactive period from March to October and the June - August interval, a period characterized by a high incidence of pedological drought phenomena (16). The average monthly temperatures for the bioactive period March - October 2021–2023 recorded values of 16.72°C (Săcuieni Meteorological Station) and 16.93°C (Oradea Meteorological Station). The highest values were recorded in July, with an average of 24°C at the Săcuieni Meteorological Station and 24.5°C at the Oradea Meteorological Station. The average monthly temperatures for the bioactive period March - October

during the research period 2021–2024 are presented in **Table 11**.

**Figure 13** graphically represents the average monthly temperatures for the bioactive period March - October, 2019–2023.

**Table 11**. Average monthly temperatures during the bioactive period March - October, 2021–2024 (data provided by ANM – Săcuieni Meteorological Station and Oradea Meteorological Station).

| Luna | Average monthly temperature - °C - 2021 - 2024 | |
|---|---|---|
| | Săcuieni Weather Station | Oradea Weather Station |
| III | +7.1 | +7.0 |
| IV | +10.6 | +10.4 |
| V | +16.7 | +16.6 |
| VI | +21.6 | +21.9 |
| VII | +24.0 | +24.5 |
| VIII | +23.2 | +23.8 |
| IX | +18.1 | +18.5 |
| X | +12.5 | +12.8 |

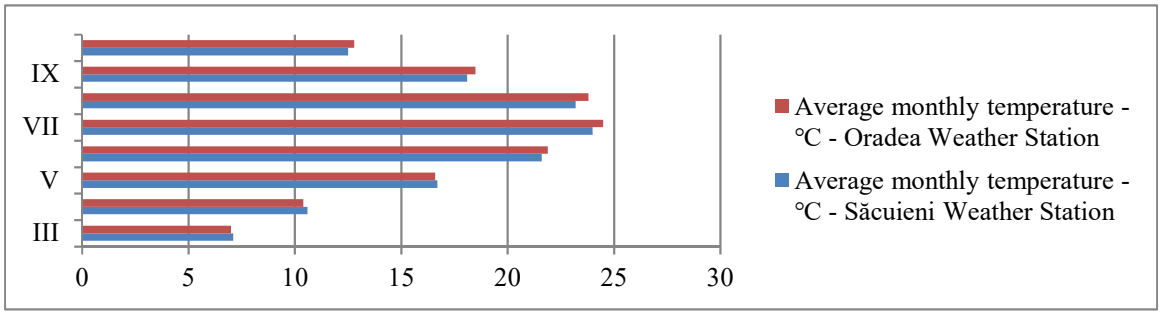


**Figure 13**. Graphical representation of average monthly temperatures for the bioactive period March – October, 2021 – 2024 (processed based on data from ANM – Săcuieni Meteorological Station and Oradea Meteorological Station).

The highest average monthly temperatures correspond to the summer months—June, July, and August—during which the phenomenon of pedological drought occurs frequently in the area (19, 20). The highest values were recorded in the year 2024. **Table 12** presents the average monthly temperatures by research year recorded during the period of maximum drought, July – August, 2021 – 2024. The graph of average monthly temperatures recorded during the peak drought period, June – August, 2021 – 2024, is presented in **Figure 14**.

**Table 12**. Average monthly temperatures by research year recorded during the period of maximum drought, July – August, 2021 – 2024 (data provided by ANM – Săcuieni Meteorological Station and Oradea Meteorological Station).

| Luna | Average monthly temperature | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 2021 | | 2022 | | 2023 | | 2024 | |
| | Săcuieni | Oradea | Săcuieni | Oradea | Săcuieni | Oradea | Săcuieni | Oradea |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| VI | +22.0 | +22.0 | +22.7 | +22.9 | 20.0 | +20.1 | 21.9 | +22.5 |
| VII | +24.3 | +24.9 | +23.8 | +24.0 | 23.3 | +23.5 | 24.7 | +25.7 |
| VIII | +21.2 | +21.8 | +23.8 | +24.2 | 23.3 | +23.6 | 24.5 | +25.7 |

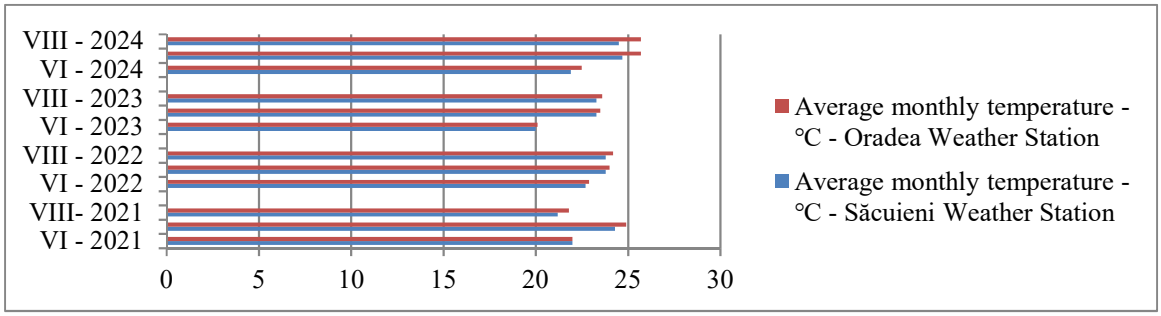


**Figure 14**. Graph of average monthly temperatures recorded during the peak drought period, July – August, 2021 – 2024 (processed based on data from the National Meteorological Administration – Săcuieni and Oradea Meteorological Stations).

### 3.2. Precipitation

The monthly precipitation recorded during the bioactive period (March – October) showed the lowest values in early spring (March) and in autumn (October), coinciding with the end of the vegetation cycle for most agricultural crops (18). **Table 13** presents the average monthly precipitation recorded during the bioactive period, April – October, 2021 – 2024 (data provided by the National Meteorological Administration – Săcuieni and Oradea Meteorological Stations).

**Table 13.** Average monthly precipitation recorded during the bioactive period, April – October, 2021 – 2024 (data provided by the National Meteorological Administration – Săcuieni and Oradea Meteorological Stations).

| Luna | Average monthly precipitation - mm - 2021 - 2024 | |
|---|---|---|
| | Săcuieni Weather Station | Oradea Weather Station |
| III | 19.75 | 22.5 |
| IV | 47 | 45.75 |
| V | 43 | 54 |
| VI | 53.25 | 57.56 |
| VII | 72 | 67.75 |
| VIII | 41.51 | 43.34 |
| IX | 64.25 | 110.5 |
| X | 19.75 | 20.25 |

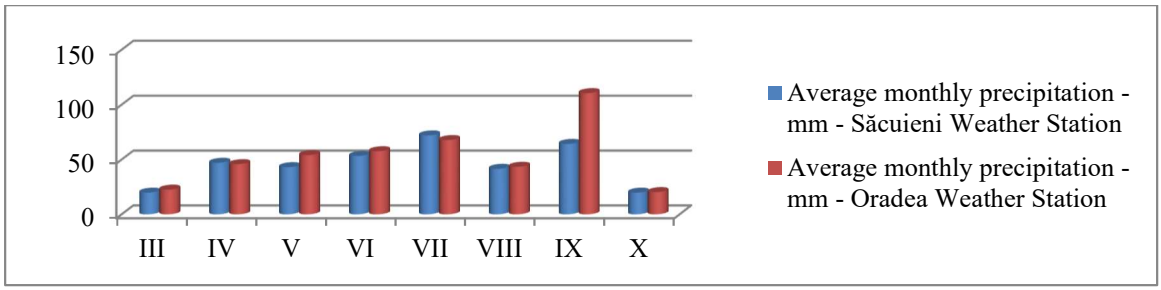


**Figure 15**. Graphical representation of the average monthly precipitation recorded during the bioactive period (March – October) for the research period 2021 – 2024.

The lowest precipitation levels during the June–August period were recorded in the years 2021 and 2024. The smallest amount of precipitation was observed in August, a month during which the frequency of pedological drought is particularly high. **Table 14** presents the precipitation values for the peak drought period, June–August, 2021–2024 (data provided by the National Meteorological Administration – Săcuieni and Oradea Weather Stations).

**Table 14**. Precipitation values recorded during the peak drought period, June–August, 2021–2024 (data provided by the National Meteorological Administration – Săcuieni and Oradea Weather Stations).

| Luna | Monthly precipitation | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Săcuieni Weather Station | | | | Oradea Weather Station | | | |
| | 2021 | 2022 | 2023 | 2024 | 2021 | 2022 | 2023 | 2024 |
| Iunie | 7.5 | 39 | 55 | 113 | 6.2 | 40 | 65 | 119 |
| Iulie | 127 | 45 | 80 | 37 | 47 | 104 | 96 | 25 |
| August | 40 | 41 | 62 | 22 | 37 | 29 | 88 | 18 |
| Total | 174.5 | 125 | 197 | 172 | 90.2 | 173 | 249 | 162 |

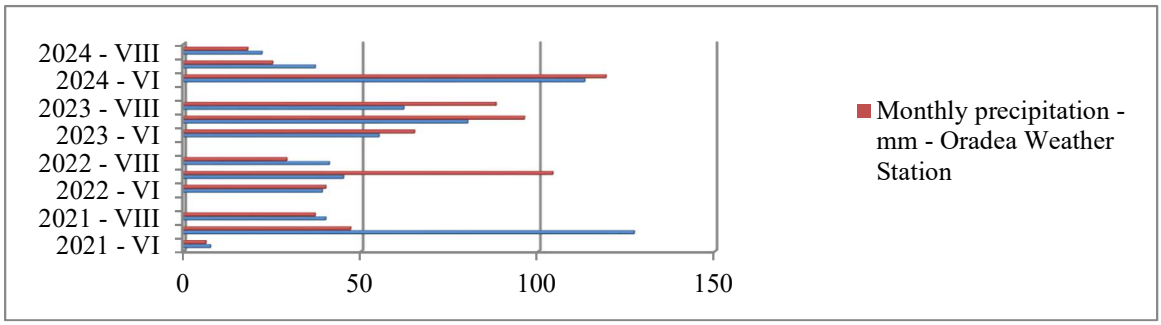


**Figure 16**. Comparative graph of precipitation during the peak drought period, June–August, 2019–2023.

### 3.3. Groundwater Excess Moisture

Groundwater excess moisture is a limiting factor for agricultural production in the Bihariei Plain, negatively impacting plant development and crop productivity. In the Bihariei Plain, fluctuations in groundwater levels within the soil profile affect an area of 762 ha, classified as Gleysols (Gleiosol – SRTS). The area of soils impacted by groundwater

excess moisture represents 17.9% of the total surface of the Bihariei Plain. **Table 15** presents the distribution and area covered by the Glezosols soil type in the Biharei Plain.

**Table 15.** Distribution and area covered by the Gleyosols soil type in the Bihariei Plain.

| Soil unit | Soil subunit | Area | Occupied area |
|---|---|---|---|
| Gleyosols - GL | Eutric Gleyosols – GL dy | 726,2 | Roşiori, Tămăşeu, Satu Nou, Biharia, Cauaceu |
| | Haplic Gleysols – GL ha | | |
| | Mollic Gleyosols – GL mo | | |
| | Fluvic Gleyosols – GL fv | | |
| | Vertic Gleyosols – GL vr | | |

### 3.4. Current Soil Acidity (pH - value)

One of the most important soil parameters is current acidity or pH, as this value significantly influences nutrient availability and microbial activity. Acidic soil pH can negatively affect agricultural crops by limiting plant access to essential growth nutrients. Out of the total area of 10,354.2 hectares in the Bihariei Plain, approximately 6,752.8 hectares have a pH value between 5.4 and 6.4. The area occupied by acidic and slightly acidic soils accounts for around 65.27% of the total surface of the Bihariei Plain. Strong and moderate acidity is characteristic of soils such as Luvisols and Eutric Cambisols. These soils are widespread in the localities of Tămăşeu, Vaida, Sântimbreu, Sălard, Hodoş, Roşiori, Biharia, and Cauaceu.

**Table 16.** Soil types and areas with moderate and strong acidity in the Biharia Plain.

| Soil type | pH value - interpretation | Surface Ha | Occupied area |
|---|---|---|---|
| Luvisols | 5,8 – 6,2 - weak acid | 2854,2 | Biharia, Cauaceu, Sălard |
| Luvisols | 5,4 – 5,8 - acid | 445,8 | Cauaceu, Sălard |
| Eutric Cambisols | 5,8 – 6,4 - weak acid | 3452,8 | Tămăşeu, Vaida, Sântimbreu, Sălard, Hodoş, Roşiori |

### 3.5. Low Nutrient Content

#### 3.5.1. Soils with Low to Medium Total Nitrogen Supply

Chemical analyses performed on soil samples collected from the arable layer of soils in the Biharia Plain revealed total nitrogen supply values, expressed as a percentage, ranging between 0.06% and 0.200%, corresponding to low to medium nitrogen supply levels. The Phaeozems soil type exhibits medium nitrogen supply, with values ranging between 0.150% and 0.200% total nitrogen. Low to medium total nitrogen supply values (%) correspond to soil types such as Fluvisols, Luvisols, Eutric Cambisols, and Gleysols. These soils present values between 0.07% and 0.15% total nitrogen.**Table 17** presents the surface areas of soils in the Bihariei Plain with low and medium total nitrogen supply.

**Table 17.** Surface areas occupied by soils in the Bihariei Plain with low and medium total nitrogen supply.

| Soil type | Area occupied | N content - % | Interpretation | Surface-Ha |
|---|---|---|---|---|
| Fluvisols (Aluviosol) | Cauaceu, Sălard, Biharia | 0,09 – 0,15 | medium | 108,4 |
| Luvisols (Preluvosol) | Biharia, Cauaceu, Sălard | 0,08 – 0,10 | low | 2854,2 |
| Luvisols (Luvosol) | Cauaceu, Sălard | 0,07 – 0,09 | low | 445,8 |
| Eutric Cambisols (Eutricambosol) | Tămășeu, Vaida, Sântimbreu, Sălard, Hodoș, Roșiori | 0,09 – 0,15 | Low - medium | 3452,8 |
| Gleysols (Gleiosol) | Roșiori, Tămășeu, Satu Nou, Biharia Cauaceu | 0.10 – 0,15 | medium | 726,2 |
| SOILS WITH LOW SUPPLY | | | | 3299,6 |
| SOILS WITH LOW - MEDIUM SUPPLY | | | | 3452,8 |
| SOILS WITH MEDIUM SUPPLY | | | | 834,6 |

#### 3.5.2. Soils with Low and Medium Phosphorus Supply

Chemical analyses conducted on soils from the Bihariei Plain regarding mobile phosphorus content revealed values ranging between 1.7 mg/100g soil and 15.8 mg/100g soil, corresponding to a supply status from very low to good. Good phosphorus supply (between 8.01 – 16 mg/100g soil) is characteristic of the Phaeozems soil type, which occupies an area of 2,552.7 hectares. Very low, low, and medium available phosphorus supply is observed in the soil types Fluvisols, Luvisols, Eutric Cambisols, and Gleysols, with values ranging between 1.7 and 8 mg/100g soil. **Table 18** presents the surface areas of soils in the Bihariei Plain with very low, low, and medium mobile phosphorus supply.

**Table 18.** Soils with very low, low, and medium mobile phosphorus supply.

| Soil type | Area occupied | mobile Phosphorus – mg/100g soil | Interpretation | Surface Ha |
|---|---|---|---|---|
| Fluvisols (Aluviosol) | Cauaceu, Sălard, Biharia | 4,01 – 8,00 | middle supply | 108,4 |
| Luvisols (Preluvosol) | Biharia, Cauaceu, Sălard | 2,01 – 4,00 | poor supply | 2854,2 |
| Luvisols (Luvosol) | Cauaceu, Sălard | 1,7 – 2,00 | very poor supply | 445,8 |
| Eutric Cambisols (Eutricambosol) | Tămășeu, Vaida, Sântimbreu, Sălard, Hodoș, Roșiori | 2,01 – 4,00 | poor supply | 3452,8 |
| Gleysols (Gleiosol) | Roșiori, Tămășeu, Satu Nou, Biharia Cauaceu | 4,01 – 8,00 | middle supply | 726,2 |
| VERY POOR SUPPLY SOILS | | | | 445,8 |
| POOR SUPPLY SOILS | | | | 6307 |
| MIDDLE SUPPLY SOILS | | | | 834,4 |

### 3.5.3. Soils with Low and Medium Potassium Supply

Chemical analyses conducted to determine the potassium supply status of soils from the Bihariei Plain, specifically mobile potassium (plant-available), revealed values ranging between 5.7 mg/100g soil and 23.4 mg/100g soil. Good supply of available potassium is characteristic of the Phaeozem soil type, with potassium values between 16 and 23.4 mg/100g soil. Low and medium potassium supply is observed in the soil types Fluvisols, Luvisols, Eutric Cambisols, and Gleysols, with values ranging from 5.7 to 16 mg/100g soil. **Table 19** presents the surface areas of soils in the Bihariei Plain with low and medium mobile potassium supply.

**Table 19.** Soils in the Bihariei Plain with low and medium mobile potassium supply.

| Soil type | Area occupied | mobile Potassium. – mg/100g soil | Interpretation | Surface Ha |
|---|---|---|---|---|
| Fluvisols (Aluviosol) | Cauaceu, Sălard, Biharia | 8,1 – 16,0 | medium supplied | 108,4 |
| Luvisols (Preluvosol) | Biharia, Cauaceu, Sălard | 6,4 – 8,00 | poorly supplied | 2854,2 |
| Luvisols (Luvosol) | Cauaceu, Sălard | 5,7 – 8,00 | poorly supplied | 445,8 |
| Eutric Cambisols (Eutricambosol) | Tămășeu, Vaida, Sântimbreu, Sălard, Hodoș, Roșiori | 8,1 – 16,0 | medium supplied | 3452,8 |

| | | | | |
|---|---|---|---|---|
| Gleysols (Gleiosol) | Roşiori, Tămăşeu, Satu Nou, Biharia Cauaceu | 8,1 – 16,0 | medium supplied | 726,2 |
| POORLY SUPPLIED SOILS | | | | 3299,8 |
| MEDIUM SUPPLIED SOILS | | | | 4287,4 |

## CONCLUSIONS

The studies and research carried out in the Bihariei Plain contribute to solving some issues related to:

- zoning of agricultural crops, taking into account the climate changes that have occurred in recent year.

- making maps and sketches regarding the main pedogenetic factors.

- obtaining and making cartograms regarding: soil properties, technological indicators of the soil and the production capacity of the soils.

- designing works for improving and restoring the production potential of the soils.

- design of works to improve trophic conditions for acidic soils

- calculation of chemical and organic fertilizer doses

- correct application in agricultural units of a differentiated agrotechnics by correlating the physical and chemical properties of the soil with the requirements of crop plants,

- design and establishment of irrigation systems, taking into account fluctuations in the rainfall regime,

- conservation and rational use of the entire land fund

- assessment and technological characterization of land areas in the Bihariei Plain

Research on climatic and pedological conditions is essential for efficient land use, environmental protection and sustainable development of the agricultural sector. Studies conducted in the Bihariei Plain can contribute to the creation of effective strategies for the conservation of natural resources and adaptation to climate change.

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