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THE IMPORTANCE OF AGROFORESTRY CURTAINS FOR ANTI-EROSION PROTECTION AND INCREASING THE PRODUCTIVITY OF AGRICULTURAL CROPS

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Abstract

The extreme manifestations of the climate in the North Baragan Plain from Romania, with major negative effects on the productive-financial results of agriculture, demand more and more obviously the need to establish protective forest curtains for agricultural crops. FAO appreciates that the forest curtains protecting agricultural land denote the degree of development of a country`s agriculture. The paper shows how forest curtains have an important role in protecting agricultural crops against drought, erosion, and landslides. According to the studies carried out, the effect of forest curtains leads to an average harvest increase of 30-55%. These results represent the effect of the influence exerted by the curtains on the significant reduction of the wind speed in the protected field. Under irrigated conditions, forest curtains increase productive transpiration by 15% and yield by up to 40% compared to fields irrigated but not protected by curtains. Also, water consumption per ton of plant mass produced is reduced by 18%, which means a reduction in the irrigation rate, thus lower costs.

Key words: *forest curtains, anti-erosion, productivity, agricultural crops.*

INTRODUCTION

The studies carried out so far have shown that the phenomenon of global warming is determined by both natural factors (variations in solar radiation and volcanic activity) and anthropogenic factors (changes in the composition of the atmosphere due to human activities). Only the cumulative effect of the 2 factors can explain the changes observed in the average global air and ocean temperature, the melting of snow and ice as well as the rise in the global average sea level (IPCC, 2007).

The increase in the concentration of greenhouse gases in the atmosphere, especially carbon dioxide, was the main cause of the pronounced warming of the last 50 years of the 20th century (0.13ºC/decade), being approximately double the value of the last 100 years (0.74ºC over the period 1906-2005), as shown by the Fourth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC, 2007), 11 of the last 12 years (1995-2006) were among the warmest in the series data recorded after 1850.

The evolution of average annual air temperature anomalies is constantly analysed by NASA, through the GISS Surface system, in the graph in Figure 1, the evolution of average air temperatures at the global level, from 1880 to the present, is presented.

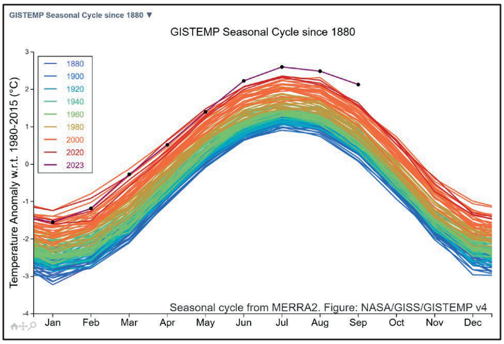

Figure 1. Graph of average monthly temperatures from 1880 to the present, compared to the reference period 1980-2015 (NASA, 2023)

The year 2023 has already become an anomaly compared to all previous years, observing decreases in temperatures in the months of January - March, and significant increases in the months of June - October, compared to the data recorded in the past. According to information provided by AFP (Agency France Presse), the year 2023 is considered the warmest year in the first nine months, global temperatures have reached new records, approaching the critical threshold of warming by 1.5°C compared to the era pre-industrial (1850-1900), which represented the period before the influence of greenhouse gas emissions produced by human activities, according to the Climate Change Service (C2S) of the European Copernicus Observatory. Thus, September 2023 was recorded as the warmest September worldwide, continuing a series of monthly records that began in June. July 2023 holds the record for all months. September 2023 significantly exceeded previous records by an extraordinary margin of 0.5°C compared to September 2020. This rising temperature trend impacted all continents, and the average sea temperature in September reached a new monthly record of 20.92°C and is the second warmest level after the one recorded in August 2023.

These alarming signals show that global responses to the climate crisis are considered insufficient, and the world is approaching a tipping point, unless immediate measures are taken for resilience to climate effects and conservation of natural soil and water resources. However, little is known about how these shelterbelts may be affected by climate change (Davis, 2014).

Mixed tree and shrub shelterbelts have better protective effect than that of single tree species shelterbelts (Cai, 2021).

In America, great progress has been made during the present century, and especially since the severe drought of 1934, in shelterbelt planting for rehabilitation of prairie farmlands. Between 1934 and 1941 four million acres of farmland were protected in the Northen Great Plains (Carborn, 1957).

Forest curtains protect wildlife in several ways, both from wind and inclement weather, and as refuge, feeding and breeding habitat, and even travel corridors. At least 108 species of birds and 28 species of mammals are known to use shelterbelt habitats (Johnson, 1988).

Also, the fact that forest curtains become sheltered within the agroecosystem, offers a strategy for increasing the efficiency of natural enemies for the biological control of pests. (Griffiths, 2008).

For organic technologies, the biological protection of fields against pests can be done by attracting insectivorous birds (Lavrov, 2021). However, in addition to the many direct economic benefits, there are numerous environmental effects, both positive and negative, that result from forest curtains.

Although not easily quantified, these environmental responses often have economic implications. Issues related to wildlife habitat and biodiversity serve as examples of the difficulty in quantifying the economic value of shelterbelts (Mize, 2008).

Also, in case of coast, fifty percent of the total forest belt especially in southern side is barren or very poor which acts as a natural barrier against the extreme events (Van Thuyet, 2014).

The change of shelter effects in oblique flows may result from (i) change of effective shelterbelt density, (ii) different efficiencies in reducing wind speed in directions perpendicular and parallel to the belt, and (iii) change of horizontal wind direction as the flow recovers to the undisturbed direction (Wang, 1996).

MATERIALS AND METHODS

In order to establish the technologies for the establishment and maintenance of forest curtains, studies were carried out regarding the thermal regime and precipitation statistics, agrochemical soil analyses were carried out, including on the soil profile, in two experimental centers (C.E. Chiscani and C.E. IMB), as well as the analysis of the pedoclimatic conditions and relief conformation, for the realization of the schemes for the placement of the agroforestry curtains. Also, a study was carried out on the species of energetic and fruit-bearing trees that lend themselves in the studied areas, at the same time developing the technological sheets for the establishment of the new agroforestry curtains. ADER project 1.2.2. is implemented by SCDA Braila as coordinator, and SCDA Turda and INMA Bucharest as partners. Based on the experimental results of the partner SCDA Turda, which has owned the agroforestry curtains for decades, the technology of planting trees in the forest curtains was realized by the partner INMA Bucharest.

RESULTS AND DISCUSSIONS

The meteorological data collected over time, from 1900 to the present at the Chiscani Meteorological Station, belonging to the Dobrogea Meteorological Center, have demonstrated a significant increase in average annual temperatures, correlated with a decrease in average precipitation in recent years, which affects from more and more agriculture and ecosystems in the Northern Bărăganu area.

The graph in Figure 2 shows the evolution of average annual temperatures recorded in the Braila Plain, in the period 1900-2022, compared to the multiannual average of 11ºC, with a significant increase from 2010 to the present.

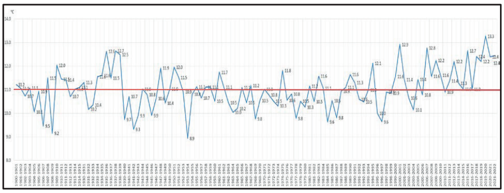

Figure 2. Graph of average annual temperatures, recorded in the period 1900-2022, compared to the multi-year zonal average.

Compared to the period 1945-2000, with average thermal values mostly below 11°C (118-year average), from 2000 to the present, thermal values have increased progressively, with a rate of 0.05°C/year.

Starting from this point, there is a prospect of an increase in the average temperature by 0.4°C until 2025 (respectively reaching the average value of 12.1°C), and by 1.6°C in 2050 (respectively reaching the average value of 13.5°C) (Figure 3).

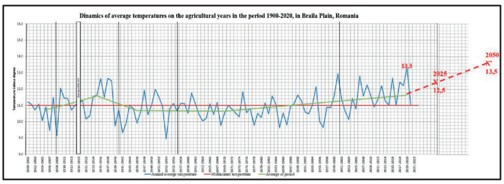

Figure 3. The graph regarding the dynamics of annual average temperatures and the prediction for the years 2025-2050

However, this perspective was modified by the climatic conditions recorded in recent years, so the average temperature recorded in the 2019-2020 agricultural year was already 13.3°C.

The solar radiation has high values, of 125 kcal/cm^2/year, being related to the duration of the sun's brightness, which in the areas of interest, respectively in Chiscani and in the Big Island of Braila, registers a number of 2200 h/year (only 75 days from a year without sun).

During the year, average monthly temperatures register a continuous increase from February to July, then a decrease from August to January, highlighting the thermal contrasts between winter and summer.

Compared to the multi-year monthly averages, which in the past showed that the air heating and cooling processes are the strongest in April and October respectively, months in which they have approximately equal values (about 6ºC), in the last two years, it was observed that April remained cooler, while October recorded much higher average values, like September's average values.

The rainfall regime in the Braila Plain and the Big Island of Braila has a very high variability in time and space, reflecting the type of continental climate. Thus, the average annual precipitations have reduced values below 500 mm throughout Baraganu, and in Brăila the multiannual average value is 442 mm. In the warm semester (April - September) 59-62% of the amount of precipitation falls, but sometimes in the last part of the summer there are long periods of drought (80-100 days).

In the cold semester, part of the precipitation falls in the form of snow, snowing on average 15-16 days and totalling 20-23% of the amount of precipitation. On average, the discontinuous snow layer persists in the Braila Plain for 40 days, with an average thickness of 10 meters, or it is even absent. The highest precipitation values are recorded in the months of May - June, and the lowest in the months of August - September.

The deficient nature of rainfall in the Braila Plain, typical of continental regions, is also reflected in the evapotranspiration regime, so the annual potential evapotranspiration values exceed the atmospheric precipitation values by about 200-250 mm.

That is why droughts in the Braila area are frequent phenomena, with cycles of dry years, so that a series of hydro-ameliorative measures are required (Figure 4). At other times, the rains overlap with the time of snowmelt causing soil erosion, damaging floods affecting land and agricultural crops.

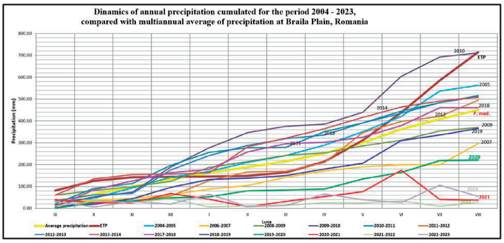

Figure 4. Graph with the dynamics of annual precipitation in Braila Plain, Romania, in the period 2004-2023

The wind is the climatic element with a particular influence in the morpho dynamics of the current processes in the Braila Plain of agricultural crops, noting that the north winds have the highest frequency, followed by the north-east and west, and regarding the wind speed keep the same order.

In winter, continental air masses originating from the Siberian anticyclone, under the name of Crivat, prevail, and in summer, Suhovei blows from the east, a warm and dry wind, which has a lower frequency, but which intensifies evapotranspiration and increases the relative aridity of the climate. On the days when the Baltaret is formed, a wall that arises due to the temperature differences between the land and the water surface, the precipitation is more abundant. Westerly winds are less frequent, winds that also bring precipitation. The average speed of the winds is relatively high, with the maximum speeds of over 100 km/h recorded during the winter, the north and northeast winds.

The implementation of the agroforestry curtains will take place in two different locations from a pedological point of view, respectively in the Braila Plain - at CE Chiscani of SCDA Braila and in the Danube Meadow, respectively in The Big Island of Braila - at CE IMB of SCDA Braila.

The Braila Plain has a relief consisting predominantly of relatively smooth fields with altitudes between 20 m and 50 m, being a low, unfragmented and poorly drained plain whose altitude drops from 40-50 m in the West to 17-30 m in the East, covered with aeolian landslides, the sandy deposits appearing on the northern edge of the plain.

The characteristics of the soil, in the Apk horizon (0-11 cm) are the following:

- loamy texture.
- very low apparent density (1.18 g/cm^3).
- medium saturated hydraulic conductivity (6.86 mm/h).
- slightly alkaline soil (pH = 8.15).
- degree of saturation in bases is 100% saturated
- low humus content (2.86%).
- medium total nitrogen content (0.156 %).
- high corrected mobile phosphorus content (50 mg/kg).
- medium mobile potassium content (174 mg/kg).
- the humus reserve in the first 50 cm has moderate values (121 t/ha).

CE IMB - The Big Island of Braila represents an alluvial plain formed at the end of the Pleistocene, with the Flemish transgression, when the level of the Black Sea rose by 5m compared to the current level, a fact that determined the heavy silting of the Danube valley downstream of Calinesti and the formation of extensive fluvial-lacustrine plains. Morphologically, the Big Island of Braila generally appears as a relatively flat plateau, where the level differences do not exceed 5 m.

The characteristics of the soil, in the Apk horizon (0-14 cm), are the following:

- clay-clay texture;
- very low bulk density (1.18 g/cm^3);
- high saturated hydraulic conductivity (34.12 mm/h).
- slightly alkaline soil (pH = 7.85).
- degree of saturation in bases is saturated (100%).
- medium humus content (4.11%).
- high total nitrogen content (0.289%).
- very high corrected mobile phosphorus content (185 mg/kg).
- high mobile potassium content (228 mg/kg).
- The humus reserve in the first 50 cm has high values (163 t/ha).

According to Law no. 289/2002 forest protection curtains are formations with forest vegetation, established by planting, with different lengths and relatively narrow widths, located at a certain distance from each other or from an objective, with the aim of protecting it against the effects of harmful factors.

The importance of protective forest curtains lies in reducing wind speed and the impact of sandstorms, reducing soil erosion, controlling salinity, mitigating carbon dioxide emissions, protecting households and agricultural land. At the same time, the protective forest curtains provide favourable conditions for the development of wildlife biodiversity and constitute an important source of wood.

Considering the risk of aridification and degradation presented by the agricultural lands in the plain area in the south and southeast of Romania and the characteristics of the network of forest curtains necessary for the most effective protection of the environment in this area, it is required that the percentage of occupation of the land with forest curtains to be approximately 2-3% (Danescu, 2018).

The eco protective and aesthetic-social functions performed by it:

- Protection of agricultural crops and increase in agricultural production.
- Forest curtains reduce evaporation and transpiration of plants, so that agricultural production in the field increases by up to 20%, even if a portion of the land is occupied by curtains. The optimal share of the area occupied by forest curtains is between 4 and 6% of the agricultural field area.
- Crop yields in non-irrigated crops - under the conditions of a slightly advanced technique and relatively young curtains, 6-10 m high.
  - for autumn wheat - between 11-143%.
  - for corn cobs - between 17-61%.
  - for autumn barley - between 19-27%.
  - for spring barley - between 10-106%.
  - for beets - between 12-45%.
  - for sunflower - between 15-28%.
  - for alfalfa for hay - between 29-36%.
  - at the barn for hay - between 21-47%.
- These increases are equivalent to the increase of the cultivated area by 12-103% in normal and dry years and by 275-1,382% in excessively dry years.

For the establishment of agroforestry curtains, species of fruit trees with value for agri-food use will be used: apple, black walnut, fragrant lime, wild/bitter cherry, chokeberry, plum, different species of fruit bushes (raspberry, blueberry, blackberry), as well as species energetic for pelletizing: energetic willow, energetic poplar, etc.

In this way, the areas of land removed from agriculture, will increase the profitability per hectare by capitalizing on fruits and pellets, at the same time as anti-erosion protection and improving the microclimate for agricultural crops.

The layout schemes of the forest curtains in the two experimental centres of SCDA Braila are represented in Figure 5, the crops scheduled for the agricultural year 2023-2024 being also specified.

CE CHIȘCANI - ARDS BRAILA

CE IMB - ARDS BRAILA

Figure 5. Schemes for the establishment of agroforestry curtains in the Chiscani and IMB experimental centres of ARDS Braila

CONCLUSIONS

- Following the analysis of the main climatic parameters of the Braila Plain, a maximum thermal amplitude of 74.5°C, among the highest in the country, a low annual amount of precipitation and an active role of the dominant wind, which increases evapotranspiration, can be found potential.
- The pedoclimatic conditions in the Braila Plain and in the Big Island of Braila demand more and more the need to establish agroforestry curtains, in the conditions of

climate changes and aridification phenomena, which are more and more evident.

- According to statistics and studies, the effect of forest curtains leads to an average harvest increase of 30-55%. These results represent the effect of the influence exerted by the curtains on the significant reduction of the wind speed in the protected field.
- Under irrigated conditions, forest curtains increase productive transpiration by 15% and harvest by up to 40% compared to irrigated fields but not protected by curtains.
- The consumption of water per ton of vegetable mass produced is reduced by 18%, which means a reduction in the irrigation rate, thus lower costs. Additionally, side effects associated with sprinkler irrigation – salinity and waterlogging – are avoided, reducing wind speed leading to improved irrigation quality.
- The project ADER 1.2.2. is intended to lead to the implementation of good practices for the establishment of forest protection curtains with the lowest possible costs and which in the future will bring both an increase in economic efficiency per hectare, but above all a resilience to climate change and the conservation of natural soil and water resources, through an adequate management of sustainable agriculture.

ACKNOWLEDGEMENTS

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