RESEARCHES REGARDING THE REINSERTION OF COTTON CULTURE IN DOBROGEA (*GOSSIPIUM HIRSUTUM L.*), CONSIDERING THE CLIMATE CHANGES, WITHIN THE CONTEXT OF SUSTAINABLE AGRICULTURE

CERCETĂRI REFERITOARE LA REINTRODUCEREA ÎN STRUCTURA CULTURILOR DIN DOBROGEA A BUMBACULUI *(GOSSIPIUM HIRSUTUM L.)*, ȚINÂND SEAMA DE MODIFICĂRILE CLIMATICE, ÎN CONTEXTUL AGRICULTURII DURABILE

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Abstract: *Cotton is a thermophile plant, whose geographical area does not exceed the 45° parallel to the north. However, at this latitude, it does not always mature. The sum of temperature degrees needed by this plant to mature is 3200-2800°C. The minimal temperature for germination is 12°C, while the sunlight duration must be at least 1 500 hours. Even though water consumption is high, cotton can withstand drought (a frequent phenomenon in Dobrogea) better than other plants such as certain cereals, for example. The fertilized cultures can withstand drought better than the unfertilized ones. Cotton vegetates normally at a rain regime of 400-500 mm yearly, if at least 200 mm and at most 300 mm fall between May-August (the rain excess during summer is harmful because the heat and light are reduced during rain, causing thus a delay in ripening and consequently a diminished production). In regards to the soil, cotton needs fertile soil with good drainage that allows air, heat and water to enter the layers explored by the roots. Currently, there are no cotton cultures in Romania, but the Dobrogea plateau offers proper soil and climate conditions in certain regions.*

Rezumat: *Bumbacul este o plantă termofilă, a cărei arie geografică nu depăşeşte spre* nord *paralela de 45°, dar la această latitudine nu reuşeşte să ajungă întotdeauna la maturitate. Suma gradelor de temperatură necesară pentru a ajunge la maturitate este de 3200-2800°C. Temperatura minimă pentru germinaţie este de 12°C, durata de strălucire a soarelui trebuie să fie de cel puţin 1 500 ore. Chiar dacă are un consum de apă ridicat, bumbacul poate rezista la secetă (fenomen meteorologic frecvent întâlnit în spaţiul dobrogean), mai bine decât alte plante, cum sunt, de exemplu, unele cereale. Culturile fertilizate rezistă la secetă mai bine decât cele neîngrăşate. Bumbacul vegetează normal la un regim pluviometric de 400-500 mm* anual, *dacă cel puţin 200 mm şi cel mult 300 mm cad în cursul lunilor mai-*august (*excesul de ploi în cursul verii este dăunător, deoarece căldura şi lumina se reduc în timpul ploilor, determinând întîrzierea coacerii şi scăderea producţiei). Faţă de sol, necesită soluri fertile, cu un bun drenaj, care să permită pătrunderea aerului, căldurii şi apei în straturile explorate de rădăcini. În prezent în România nu se mai cultivă bumbac, însă podişul Dobrogei oferă în anumite regiuni condiţii pedoclimatice propice.*

***Key words*:** *cotton, marine aquatorium, favorable climate, fertile soils, drought resistance*
***Cuvinte cheie*:** *bumbac, acvatoriu marin, climat favorabil, sol fertil, rezistență la secetă*

INTRODUCTION

Considering that during the 1960s-1970s cotton (*Gossipium hirsutum L.*) was cultivated on large surfaces in Romania, with productions comparable to those obtained at international level, and also that the Dobrogea plateau offers goods conditions for this culture,

there is the possibility that cotton may be cultivated on large surfaces in this geographical area in the future.

MATERIAL AND METHODS

The paper analyzes the pedo-climatic conditions in Dobrogea and the requirements of cotton (*Gossipium hirsutum* L.). Also, data were collected from the meteorological stations in the studied perimeter and, by comparison with the cotton requirements in terms of climate and soil, a cultivation technology was elaborated that can be applied to this culture. Recommendations were also made regarding a possible reintroduction of this plant in the culture structure in Dobrogea.

The climatic characterization of Dobrogea is based on the results from recordings taken from 18 meteorological stations. Among these, 12 had an observation period of 46 years (1967-2007), while 6 of them had a shorter observation period, between 8-15 years. Among them there is the meteorological station on the Gloria drilling platform, which provides especially precious data for the marine activity and particularly for the naval traffic and the prospects needed for the hydrocarbons exploitation.

RESULTS AND DISCUSSIONS

For the most part, Dobrogea fits in the climate layer of hills and low plateaus, under 500 m altitude (North Dobrogea) and in the climatic layer under 200 m altitude (Central and South Dobrogea). By its presence, in the south-east of Romania, directly next to the Black Sea (at the east) and the Danube Valley (at the west and north), by the complexity of the active surface structure, over which the influences of the main pressure centers overlap (the Mediterranean and Pontic cyclones, the Azorean, Scandianavian and Euro-Asian anti-cyclones), Dobrogea is characterized by the most typical temperate-continental climate in the country. This climate has traits similar to that in the Ukraine steppe in the north of the Black Sea and to those of the Pre-Balkan plateau in the south, compared to which, it is a transit area.

The semi-arid character of the climate is determined by general causes (solar radiation and general circulation of the atmosphere) and local causes (the characteristics of the active surface structure). The main climatic parameters for the phenological evolution of cotton culture are:

Average of yearly temperatures. Its values (1961-1007) are of approximately 11°C on the west side (Cernavoda 10.9°C, Harsova 11.0°C) and over 11°C on the north-east side (Tulcea 11.0°C) and east (Sfantu Gheorghe and Gura Portitei 11.4°C, Tuzla 11.2°C, Constanta and Agigea 11.3°C and Mangalia 11.2°C).

The average temperature in July. This has territorial variations of approximately 2^0C. The average temperature in July diminishes from south to north, with the increase of altitude and continental influences: Adamclisi and Basarabi 22.2°C, Corugea 21.4°C. Locally, under the influence of limestone or shelter, these values exceed 22.5°C (Harsova and Tulcea 22.7°C and Mircea Voda and Isaccea 22.8°C, respectively). They decrease with the altitude below 21°C. At the seaside, under the influence of the sea, there are two possibilities: south of Cape Midia, the temperature is approximately 22°C (Constanta 22.1°C, Mangalia 21.7°C), same as in most parts of North and Central Dobrogea; north of Cape Midia, where the values of sunshine and solar radiation are higher, the heating processes are more obvious. The sub-tropical heat waves of north-African, Mediterranean or south-east continental origin or the sub-polar cold waves determined positive and negative deviations of the temperature in this month, less spectacular, compared to the winter ones of only 2-3°C.

Cotton is a thermophile plant, whose geographical area does not exceed the 45° parallel in the north. However, at this latitude it does not always reach adulthood. The sum of

temperature degrees needed for maturity is 3200-2800°C. The minimal temperature for germination is 12º (14°C according to some authors). Between sowing and flowering the plant needs approximately 65 days, during which it needs an amount of warmth of approximately 1350°C. 50-55 days pass between the first flowers and the opening of the first capsules. Cotton is particularly sensitive to warmth; it dies at temperatures below 0°C; the late spring frost and the early autumn frost limit the time interval the cotton needs to vegetate. In the south, its vegetation period is between April 15th and October 15th, which means a total of 180 days; thus the precocious types can reach maturity. At temperatures below 10°C the plant does not die but its organs suffer. For example, if the soil temperature is 3-4°C, the root cannot absorb water, the plant withers and dries in time. Temperatures over 35-37°C determine growth stagnation and then withering.

Atmospheric precipitations. They are one of the most important elements of the climatic potential of the region and a limiting factor for cotton culture, with different characteristics compared to the rest of Romania. These characteristics are given by the position of the region at the extremity of the influence pressure centers: the Azorean anticyclone, at whose periphery the oceanic cyclones develop, (and which are responsible for the main pluviometric maximum in June), the east-European anticyclone (even though it has a considerable influence on the region, it does not cause rain) and the Mediterranean and Pontic cyclones, with retrograde character, the only ones capable of abundant rain (downpour), which can determine the second autumn annual pluviometric maximum.

On the other hand, the Black Sea is not only a center of cyclogenesis that can generate rains. Most of the time it is a huge aquatorium, whose role is to be a "thermal dam" because of the temperature inversions caused by the evaporation processes which contribute to the destruction of the cloud systems and obvious reduction of the rain quantity. This influence is felt on the surrounding regions. Consequently, in the Dobrogea Plateau they decrease from west to east. Also important here are the Danube influences, which exercise the major Black Sea influences on a small level. There is also the three-layered landscape with peripheral exposure, subject to influences from all sides: continental, sub-Mediterranean, Pontic and Danubian.

All these justify why the Dobrogea Plateau is for Romania the territory with the smallest average annual rain quantities. They decrease from 400-450 mm in the westernmost part to 350 mm in the littoral area and even below this value on the nearby continental platform (330.5 mm in Sulina-seawall).

Evident from this point of view are the two west-east profiles which follow the northern extremity of the area, continued with the Danube Delta: Isaccea 444.7mm, Tulcea 438.4mm, Gorgova 406.9mm, Sulina-city 359mm, Sulina-seawall 330.5mm and the alignment of the Carasu Valley, respectively: Cernavoda 463.8mm, Medgidia 414.3mm, Valu lui Traian 391mm and Constanta 382.6mm.

In the North and Central Dobrogea Plateau, because of the altitude, the average annual rain amount increases to 500mm, and on the highest peaks of over 350-400m, rain reaches 550mm, amount equal to the one in the forest steppe in the western extremity of Baragan.

In South Dobrogea and Oltina Plateau, respectively, with higher altitudes (approximately 200m) and sub-Mediterranean influences, the annual rain amounts rise over 450mm.

Of the annual rain quantity, less than 2/3 (180-250mm) is produced in the warm semester of the year (April-September), while the rest of over 1/3 (150-200mm) is produced in the cold semester of the year.

Over the year, the monthly rain amount (1901-1990) records a main pluviometric maximum in June with the lowest values along the littoral (Sulina-city 43mm, Sulina-seawall

35.9mm, Gura Portitei 36.1mm, Constanța 41.7mm, Mangalia 56.4mm) and the highest values in the west sector (Cernavoda 60.8mm, Harsova 56.4mm), north sector (Isaccea 46.5mm, Tulcea 53.5mm, Mircea Voda 54.4mm, Corugea 52.6mm) and south-west sector (Adamclisi 61.4mm). A second annual pluviometric maximum (smaller values of 30-40mm) is produced on the littoral and Oltina Plateau in autumn, with influences from the Pontic and Mediterranean cyclones. Apart from the cyclonic rains, there are also frontal rains in the area and especially convective ones with continental character (downpour). They occur in an anti-cyclonal regime because of the strong insolation which generates Cumulonimbus clouds with vertical development which produce highly erosive rains, sometimes hail, thunder and lighting.

Such rains are specific, especially to North and Central Dobrogea, territories covered with friable loess deposits. The field researches demonstrated that during the respective downpours with strong mechanical action, the hydrographic basins increase by regressive erosion and the valleys widen by a few meters vertically up to the basic rock; at the same time a large quantity of sediments flows along them. The maximum rain quantities in 24 hours have a very important role from this point of view. The absolute monthly values are in all cases higher than the multi-annual monthly means, sometimes, especially in the littoral zone, even twice or three times higher.

From the water point of view, cotton is characterized by a relatively high consumption, the transpiration coefficient being up to 350-650. The highest demands occur at blossoming time, when the consumption is almost double compared to other vegetation phases. At least 50% of the total water quantity is consumed during the blossoming period and when the capsules open [1].

In spite of the high water consumption, cotton can withstand drought better than other plants such as some cereals. The fertilized cultures withstand drought better than the unfertilized ones. Balan (1949) showed that cotton vegetates normally at a rain regime of 400-500mm annually, if at least 200 mm and at the most 300 mm fall between May-August (the rain excess in summer is harmful because the heat and light are reduced while it rains and this determines the delay of ripening and the reduction of the production.

The wind is another element of the climatic potential that can compete as major cause to dryness and drought and that can influence positively or negatively the evolution of the cotton culture. It is dependent on the characteristics of the general atmospheric circulation, as well as on the influence of the surrounding continental and maritime regions. There is also the role of orography and landscape morphology that direct the air currents. Consequently, at the western extremity of the region, nearby the Danubian passageway, the wind has maximum frequency (1961-2007) from the north, direction imposed by the orientation of the Danube Marshes (Harsova 18.9%), while at the eastern extremity the directions are: north (Sulina 18.5%, Jurilovca 27.9%) and south (16.7% and 10.7%, respectively), imposed by the presence of the Black Sea and the absence of obstacles; on the southern littoral, the predominant directions are from the west (Constanta 15.1%) or north-west (Mangalia 16.7%).

The north-west predominate in the North Dobrogea Plateau, the east and west in the Casimcea Plateau (Corugea 15.1% and 14.4%, respectively), while the north and west predominate in the South Dobrogea Plateau (Adamclisi 13.5% and 12%, respectively).

Atmospheric calm has the highest annual average frequency in South Dobrogea (Adamclisi 22.5% and Valu lui Traian 23.9%) and the lowest at the eastern extremity of the Danube Delta (1.8%) where the wind has the highest frequency, which influences negatively the cotton culture. On the southern littoral, the annual frequency of the calm rises to 10-15%. Inside the Dobrogea mainland, the calm value decreases with the altitude (Corugea 10.9%).

The solar radiation is determined by the solar activity. The average values of the solar radiation per year are influenced by the general circulation of the atmosphere, which

represents the main mechanism that causes the formation of clouds and which determines the variation of the insolation processes. As a result, the average sunshine period per year varies from 2200 hours of insolation to the west, to 2300-2400 hours of insolation to the seaside. Here, under the influence of the sea, of the Razim-Sinoe Complex and of the Danube Delta water surfaces, the value rises up to 2500 hours of insolation. The duration of the insolation also determines the average value of global solar radiation per year. The values of the latter rise about 127.8 kcal/cm^2 in the westernmost point of the Dobrogea Plateau, to 132.5 kcal/ cm^2 in the easternmost point. All along the year, over 2/3 of it is produced during the hot semester of the year, which favors the balneoclimatic treatment and the touristic activities along the seashore. The sunshine period must be of at least 1500 hours. In Egypt, it is of over 2000 hours, during the 7 months of vegetation, the fibres thus formed being of extremely high quality. Cotton is a short day plant and it blooms and produces fruit normally only if it is exposed to daylight for 10-12 hours during a certain number of days, which can vary depending on each type.

As far as the soil is concerned, it requires fertile and well drained soils, which permits the air, the warmth and water to enter the layers where the roots grow [2]. Cotton is not productive on dense clay soil, on soil with shallow underground water (situated at less than 100 cm from the ground surface), on damp or cool soil, as well as on sandy and salty types of soil. The best kinds of soil are the chernozems, the light-brown steppe soil, the sediments. The reaction should be neuter of slightly alkaline.

Studies and recommendations regarding the technology for cotton cultivation in Dobrogea

Considering the plant's high demands in terms of warmth, light and food, cotton can have acceptable results in our country if the cultivation technology applied is impeccable.

Rotation. The experiments accomplished at Brinceni station showed that cereals and weeders are good previous plants for cotton, while the seed legumes (peas, beans etc) must be avoided because too much nitrogen in the soil delays maturity. After cotton itself, it can be cultivated for 2 years at most. Spring plants, mostly cereals, can be cultivated after cotton.

Fertilization. The most intense absorption occurs in the bud period and the beginning the fruit formation, which is June 15th –August 15th. During this interval, the plant consumes 60-65% of the total needed quantity of N, P and K. It is recommended that, considering the Romanian conditions, all the necessary measures be taken in order to ensure maturity before the fist early autumn frosts that have been occurring in mid-October lately. An important element is keeping a good proportion between nitrogen and the other nutritive elements.

Soil tillage. Cotton prefers deep tillage, the optimum depth being 25-30 cm. The tilling moment is very important. The rough tillage, executed in late autumn, reduces the cotton production and stresses the ripening unevenness. In the spring, the soil must be tilled by harrow and leveled as soon as it is permitted. By sowing time, the soil is kept loose at a depth of 10-12 cm, with the plough, in order to facilitate its heating. If the earth is settled again, another shallow tilling is needed before sowing, at the sowing depth, at the same time with leveling.

The seed and sowing. The quality of the seed used for sowing is an important factor on which the size of the production depends. The initial contact between the seed and the sulfuric acid must be limited to 12-15 minutes, after which it is washed away with plenty of water. The *time* to sow is when the soil, at a depth of 10 cm, has a temperature of at least 12-14°C and the danger of late frost has passed. These conditions are met starting with April 25th and the optimal sowing period only lasts for about 10 days [5]. The *density* of the cotton culture, established as a result of experiments done in its culture area in Romania, is 11-12 plants/m^2. In order to accomplish this density, it is necessary to use 4 times more germinable seeds because some of the seeds do not sprout, others generate unviable plants, others cannot

emerge or die from different causes. The quantity of seed used to sow one hectare is 60-70 kg. A sparse culture must be avoided because low density offers the plants too much nutritional space and so they prolong their vegetative cycle and the ripening is delayed. *The sowing depth* is 5 cm., deeper sowing is not recommended because the seed has little power to break the soil.

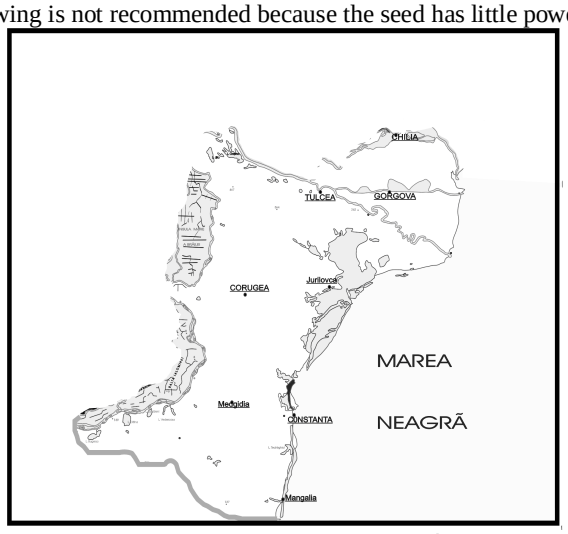

Figure 1. Favorabilitatea culturii bumbacului în Dobrogea

Conclusions

The pedo-climatic conditions in Dobrogea allow the reintroduction in culture of cotton in the west side, as well as in the aero-dynamic shelter (fig. 1).

The average annual temperatures, as well as the temperatures recorded for the cotton vegetation period are suitable for the reintroduction of this culture of great economical interest in the culture structure, which is poorly represented in this climate area of Romania.

The rain fallen in the cotton vegetation period in Dobrogea satisfies the water requirements of the cotton culture.

The cultivation technology recommended for cotton culture can be successfully applied by the farmers in Dobrogea, if the necessary mechanical means are acquired.

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