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DOCTORAL THESIS ABSTRACT

RESEARCHES ON THE IMPROVEMENT OF THE WATERMELONS CULTIVATION TECHNOLOGY ON SANDY SOILS FROM SOUTH OF OLTENIA

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ABSTRACT

The vegetable farming on the sandy soils of Southern Oltenia represents for our country a field with a special importance and a high degree of intensity. It has major implications in the alimentation of the population and, especially, in the national economy, and it is represented by a vast area of over 100,000 ha of sandy soil, located between Calafat, Poiana Mare, Sadova, Bechet, Dăbuleni and Danube, known as *Sahara of Oltenia. Dăbuleni is the only place in the world where there is a museum of sand, specially arranged to make a comparison between the sandy soil with moving dunes and the one with irrigation system.* The sandy soil of the area has special qualities in terms of temperature conditions which is the main factor of its topoclimate.

The premise used for approaching the theme of this doctoral thesis *starts from the idea that the principles of agroecology become also fundamental principles for the development of a green economy, especially in the context of the current climate changes, the efficient utilization of the ecological conditions of the sandy soils being one of the main objectives of the agricultural science and practice. Identifying and formulating adaptive technological solutions can guide any manufacturer to capitalize on different climate and soil conditions. The areas with sandy soils in Southern Oltenia offer less favourable ecological conditions, and the cultivation of watermelons makes these conditions quite profitable at present. However, the growers are interested in getting as many yields as possible, early and profitable, even in the context of climate change.*

Dăbuleni is located in the south of Oltenia plain, at the south of the 44° North parallel, in a sandy area which is the warmest part of Romania. It offers ***favourable conditions for the cultivation of watermelons*** through its topoclimate. Due to this species' importance in alimentation and due to the fact that it is a fresh vegetable in the coldest periods of the year, but also due to the fact that it capitalizes very well the sandy soils in Romania, the extension of the researches on this species ***is fully justified***. **The PhD thesis entitled "RESEARCHES ON THE IMPROVEMENT OF THE WATERMELONS CULTIVATION TECHNOLOGY ON SANDY SOILS IN THE SOUTH OF OLTENIA"** aimed to improve the diversity of varieties and hybrids of watermelons in order to capitalize more efficiently the cultures in the Dăbuleni area in the context of climate change, and to improve the technological links – planting density, grafting - in order to cultivate watermelons on the sandy soils of Dăbuleni, offering a niche of ecological adaptation to the producers in the area. In order to achieve the proposed aim, specific objectives were outlined as follows:

The first specific objective of these researches relates to the comparative crop study of an existing assortment of varieties and the newest hybrids of watermelons, tested for the first time in the Dăbuleni area, which are found in some countries that are the largest producers of watermelons. These hybrids, by their genetics, have the ability to capitalize in a profitable manner the microclimate conditions specific to the sandy soils in the south-west of Oltenia, where the experiment was placed and ultimately to increase the economic efficiency of this culture. ***The second specific objective*** is to obtain early yields with grafted plants, increasing the resistance of plants to abiotic, thermo-hydric stress

factors, improving their resistance to low temperatures, heat, drought. ***The third specific objective*** was to determine the optimal planting density of watermelons according to the cultivar and the type of crop.

The paper is structured in two parts, namely **PART I. THE STATE OF KNOWLEDGE**, including chapters 1, 2 and 3, meaning 41 pages from a total of 257 pages and **PART II. OWN RESEARCH** - chapters 4, 5, 6, 7., including also the Introduction, Conclusions, recommendations and the Bibliography. The thesis includes 170 tables and 102 figures, 155 bibliographic references from the approached field, including the 7 scientific papers published within the topic of the thesis during the doctoral studies.

The chapter 1, entitled **"The origin, distribution and importance of watermelon"** briefly presents the disparate aspects regarding the origin of watermelon, its food and economic importance, as well as the current situation of the cultivation of watermelons, taking into consideration the fact that Romania is the third producer of melons in the European Union after Spain and Greece. It is observed that the watermelon occupies an important place worldwide in terms of cultivated areas and consumption per capita of watermelon fruits. The highest per capita production is 42.6 kg in Romania, followed by Turkey with 36.1 kg/inhabitant and Spain with 18.4 kg/inhabitant (FAO Yearbook 2015).

Chapter 2 "Botanical particularities, plant relations with environmental factors and watermelons cultivation technology" describes the important botanical and biological features for practice, the requirements for environmental factors - emphasizing the importance of knowing the existing relationships between the species and the complex of environmental factors, the classical technology of watermelons cultivation, from seedling technology to indications of optimum harvesting time, taking into account aspects such as: when the tendril at the bottom of the fruit twists, it dries from the top and does not have any more hairs; when the epidermis (on the outside) is scratched easily; when the fruit is easily removed from the stem; when the part of the fruit in contact with the soil becomes white or yellow; when knocking with the finger it does not sound empty; when it is pressed and a crash is heard. The fruits are harvested in the morning, on cool weather, from 4 to 4 days, with a total of 3-5 harvests, with different production, 40-80 t/ha, depending on the cultivar.

The third chapter entitled **"Studies on the modern methods development of productivity growth in watermelon plants"** presents the stage of researches on the cultivation of watermelons on sandy soils, starting from the idea that the sandy soil area in southern Oltenia represent a micro-zone in which the vegetables find particular conditions in comparison to the ones found on zonal soils, conditions that determine some particularities of the vegetables cultivation, then the grafting of the watermelons as an important technological link, the necessity of grafting, the stage of research on the watermelons grafting and the grafting methods of the watermelons, stating that the specialized literature in our country has few data on the vegetables grafting in general and of watermelons in particular, the method being little used by the growers in the area, which confirms once again the opportunity offered by this PhD thesis. The grafting offers

resistance to the *Fusarium oxisporum* fungi and nematodes attack, increases the plant vigor, early sunflower, tolerance to thermal and water stress, improving the fruit quality, including the increase of the nutritional value, once with the growing concern that horticultural practices will not harm the environment. It is an efficient biotechnology and helps to obtain unpolluted productions. It is also presented the fertirigation as a method of increasing the productivity of watermelons, emphasizing the importance of drip irrigation, with advantages but also disadvantages, including the extra costs after harvesting.

The chapter 4 "Particularities of climatic and soil resources in which experiments took place" presents a general characterization of sandy soils in Romania, of sandy soils in southern Oltenia, showing the peculiarities of the environment in which the experiment was conducted, specifying that the conditions of desertification appear in the dry years, but they do not appear in the rainy years, presenting general data on the physical, hydrophysical and chemical properties of the sands in the southern Oltenia. The area occupied by sands and sandy soils is considered controversial in terms of surface according to various authors. According to the latest data provided by the Research Institute for Pedology and Agrochemistry, it has 439 thousand hectares, out of which the total agricultural area is 381 thousand hectares. The results of a new and welcomed study carried out during the doctoral program on the main climatic elements that characterize the area with psamosoils in the south of Oltenia from a climatic point of view, for a period of 31 years - 1987-2017, is also presented in chapter 4.

The climatic data from the archive of the meteorological station located in the the Research- Development Center for Agricultural Plants on Sands Dăbuleni (C.C.D.C.P.N. Dăbuleni) were analyzed and processed. The climatic data from **1987 to 2017** were studied, i.e. a period of 31 years, sufficiently large for a meaningful analysis and accurately formulated conclusions, so the data was processed for the 372 months and 2232 data records. The **Helmann criterion** was used to determine the thermal and pluviometric time types, and for the normal climatic averages there were used the 31-year average measurements. Major climatic aspects are quantified and concluded, such as: ***The absolute climatic record of the earliest spring in Dăbuleni*** area is in the spring of 2016, with an absolute spring index of ***583.1*** ($\sum$ daily average temperatures $\geq 0°C$ from 1 February to 10 April); ***the hottest months have been recorded since 2000, confirming the global climatic warming*** starting especially with this year, with only one exception (September 1994). The long hot periods began with the year 2000, the year when the criteria for assessing the types of thermal time changed according to the new climatic evolutions.

April 2002 holds the climatic record of the average maximum temperature in the history of climate observations, not only in Romania but in a large part of the northern hemisphere. *The chart of the annual rainfall variation* has a strong upward trend and the growth rate is particularly significant, confirming **a trend of annual rainfall growth. This is due to the climatic warming process, which leads to the surpassing of the climatic parameters in both directions (for both low and high values), the warmer atmosphere containing a higher amount of water vapors, and the torrential rains becoming more frequent and intense as the hot periods and the heat waves that become more frequent, intense, and longer. All these aspects show the need for crop irrigation in this area.** It can be concluded that the climate warming is also present

in the Dăbuleni area during all the months of the year. Only January has an average negative temperature, and **the average temperature increases from February to March with 5.0°C (while in other parts of the country the increase is lower), with 6.1°C from March to April and with 5.5°C from April to May, with the highest increases throughout the year, thus supporting the rapid and continuous development of the watermelon crops.**

The **5th chapter "The necessity and objectives of the research; research methods and materials"** includes aspects regarding the opportunity of choosing the research theme by formulating the general objective and the specific objectives, in order to identify new solutions and methods regarding the improvement of the technological sequences of watermelons cultivation and to increase the economic efficiency of this culture.

The researches were carried out during the 2015-2017 period, through the elaboration of a research program under the pedoclimatic conditions in southern Oltenia, at the Research- Development Center for Agricultural Plants on Sands Dăbuleni, comprising two experiments. **Experiment I** - *Researches on the behaviour of some watermelon cultivars on sandy soils in the south-west of Oltenia (Dăbuleni)* included 12 cultivars, of which 3 native ones *(Dăbuleni, Dulce de Dăbuleni, Oltenia)*, created at the Research- Development Center for Agricultural Plants on Sandy Soils Dăbuleni and 9 new hybrids of foreign origin (*Susy F1, Baronesa F1, Oneida F1, Huelva F1, Carroll RZ (62-269)F1, Fantasy F1, Tarzan F1, Grand Baby F1, LF 670 F1*). The experiment was monofactorial and was placed in the experimental field by the randomized block method in 4 repetitions. In the **experiment II** – *The influence of the planting density of the watermelon according to the cultivar and the type of culture* - three factors were analyzed namely the genotype - the *Romanza F1* hybrid and the *Oltenia* variety, the type of culture - with grafted and non-grafted plants and the planting density -5000 plants/ha, 4000 plants/ha and 3000 plants/ha. The experiment was trifactorial and was placed in the experimental field by the randomized block method in 4 repetitions. The technology of producing grafted plants seedlings of watermelon is also presented. The grafted seedling required to set up the experiment was produced in the double-shielded greenhouse. The technology applied to the two field experiments is also presented.

The researches have determined the soil fertility status of the experimental parcels, the biometric measurements, and the physiological, biochemical and production determinations were conducted in one or more stages. The determination of the soil fertility status of the experimental parcels was made by determing the content of the following elements: content in organic matter, nitrogen, potassium, phosphorus, soil pH. The morphological and production determinations of the watermelon plants concerned: the length of the stem; the apparition date of the first flowers and fruits; the highlight of the production dynamic of each variant; the number of fruits per plant; the determination of the average weight of the fruit; the determination of the total production by variants and experiments. The determination of some physiological processes and indices included: photosynthesis rate; transpiration rate. The biochemical determinations of the watermelon fruit concerned: water content; total dry matter content; the soluble dry

matter content; carbohydrate content; vitamin C content, total polyphenols, titratable acidity, conductivity, pH.

Chapter VI presents the results on the **"Pedoclimatic conditions of the 2015-2017 experimental period "**. In order to provide an answer to this theme, observations and determinations were made during the 2015-2017 period, being presented for each year of study and as an average over the three years. The three years of research have been very different in terms of climate. The lowest temperature was recorded in 2015 immediately after planting, being associated with rainfall and hail, affecting the seedlings. They were affected and they have been recovered with difficulty, even if the minimum temperatures have not been below the biological threshold in the next period, and they did not make good use of their productive potential, thus explaining the low yields in this year. In June 2015, ***phenomena of scorching heat and heat*** were recorded even though the month as a whole was cold. In the other two decades, the maximum temepratures exceeded 30.0°C, with ***tropical days*** recorded in August. *The monthly maximum temperature* was 37.1°C, being recorded in the second decade, on 16 August. The maximum temperatures in the other two decades were 36.1 and 36.5°C, indicating that ***the scorching heat and heat were frequent phenomena in August 2015. The 41.2°C is a climatic record of June 2017 for the whole country, being the only value ≥ 40.0°C in Oltenia (also in the country) registered in June 2017, which shows a particularly warm topoclimate compared to the rest of the country due to the sandy soil whose albedou is 35-43%, reflecting much of the incidental solar radiation and thus heating the air.*** This fact has led to a rapid development of the watermelon culture. During the research period (2015-2017), the average air temperature was 20.43°C, and the warmest period of vegetation after the average vegetation period was in 2016 with a general average of 20.68°C, but the higher monthly maximum temperatures were recorded in 2017, when June, July and August had monthly maximum temperatures > 40.0°C (41.2°C, 40.8°C and 40.4°C). 41.2°C is *the climatic record for June 2017 for the entire country. The average rainfall* in the three-year vegetation season was 337.5 l/m^2, which represents 46.1% of the average of the three years - providing the proper conditions for the watermelon culture. The rainfall excess time was equal to that of the rainfall deficiency time for the total of 18 months of experimental research, 9 months in each category (50.0%) and 0.0% normal rainfall time; the lowest values were recorded in 2016, when the total amount of precipitation was 288.0 l/m^2.

Chapter VII "Results" is structured on two subchapters, where the results from **Experiment I. The researches regarding the behaviour of some watermelon cultivars on sandy soils in the south-west of Oltenia (Dăbuleni)** are presented as following: average values of the growth and fructification elements of the studied watermelon cultivars, the physiological determinations - the intensity of photosynthesis and transpiration, the biochemical determinations of the watermelon fruits, the production determinations. Under the conditions of the **year 2015**, the *Fantasy F1* (5.3 kg / fruit) hybrid was outlined due to the weight of the fruit, *the Fantasy F1 and Huelva F1 hybrids* due to the earliness, and due to the obtained productions there were remarked *Fantasy F1* with a production of 34.7 t/ha, *Dulce de Dăbuleni* with 33 t/ha and *Huelva F1* with 30.3 t/ha. In 2015, a cool and less favourable year, the intensity of photosynthesis is generally

lower. The cultivars that maintain the higher value of photosynthesis are *Fantasy F1* and *De Dăbuleni*. The transpiration water losses are also lower in conditions of low temperature and high relative humidity. *De Dăbuleni, Dulce de Dăbuleni and Oltenia* varieties recorded the lowest level of transpiration, and the *Fantasy F1* and *Susy F1* hybrids recorded the highest level of transpiration. **The year 2016** was favourable to watermelon culture, the productions were higher than in 2015, outlining *Baronesa F1* and *62-269 F1* hybrids with 47.9 t ha, *LF 6720* with 44.9 t/ha, the *Oltenia* variety with 43.6 t/ha, and the *Huelva F1* hybrids with 41.8 t/ha and the *Grand Baby F1* with 41.6 t/ha. The year 2016 was a favourable year for watermelon plants, with physiological processes being more intensely than in 2015, with the photosynthetic maximum being recorded by the *Oneida F1* hybrid. This hybrid has recorded also a maximum rate of photosynthesis, using effectively the evaporated water through leaf transpiration. Under the conditions of **2017**, the earliest and highest production was recorded by the *Fantasy F1* and *Susy F1* hybrids. *De Dăbuleni, Dulce de Dăbuleni and Oltenia* varieties of watermelon recorded the highest production in 2017, the *Oltenia* variety recording a production of 55.6 t/ha. The *LF 6270 F1, Tarzan F1, Oneida F1 and Grand Baby F1* hybrids could not adapt to the climatic conditions of this year, recording very low productions. On average, over the three years of research, the *Fantasy F1, Susy F1 and Huelva F1* hybrids have been noted by earliness, and the *Oltenia and Dulce de Dăbuleni* native varieties and the *Baronesa F1, Huelva F1 and Tarzan F1* hybrids recorded high productions. The year 2017 was a particularly hot year, the physiological processes in the plants developing with maximum intensity. The largest accumulations of organic matter through the photosynthesis process were recorded in the *De Dăbuleni* and *Dulce de Dăbuleni* native varieties. *De Dăbuleni* and *Oltenia* varieties recorded the lowest losses of water through transpiration, which shows their high degree of adaptability to natural conditions. The highest transpiration rates were recorded in the *Grand Baby F1* and *LF 6720 F1* hybrids. It should be noted that the cultivation of these hybrids should only be done under the conditions of a system of irrigation, because the loss of water through transpiration leads to the debilitation of the plants and ultimately to their death if the irrigation is not applied to the crop. ***The Romanian varieties have a higher degree of adaptability due to lower transpiration.*** The second subchapter presents the results obtained in **Experiment II. The influence of planting density on the cultivation of watermelon according to the cultivar and the type of crop**, using grafted plants from two cultivars, *Oltenia* a native one and *Romanța F1* an imported hybrid, grafted on the *Macis F1* rootstock and grown using three crop schemes, resulting in 5000, 4000 and 3000 pl/ha. The average values of the three years of research (2015-2017) were statistically interpreted using the Multiple Comparison method between variants of variance-based values, the calculation of correlation coefficients between the analyzed characteristics, the calculation of regression coefficients, and the drought tolerance indices. ***The drought sensitivity of the two cultivars was studied according to the type of crop and the number of plants at the surface unit*, elements that have not been studied until now on the sandy soils from Dăbuleni**, establishing four indices presented also in the literature, namely: the sensitive drought index SDI, the relative drought index RDI, the yield stability index YSI, and the drought resistance index DI. Following the observations and determinations made during the three experimental years (2015-2017) in the

watermelon culture which was organized as a trifactorial experiment with: factor A-cultivar, with two graduations (a_1 - *Romanza F1* hybrid and a_2 –*Oltenia* variety); factor B - type of culture, with two graduations (b_1 – non-grafted culture and b_2 - grafted culture) and factor C – the planting density with three graduations (c_1-5000 pl/ha, c_2-4000 pl/ha and c_3-3000 pl/ha). Some conclusions can be drawn such as:

- considering the influence of the studied factors and their interaction on watermelon production, the a_2 and c_2 graduations significantly influenced the total fruit production, while in the case of the interaction of the 3 factors, the variants a_2b_1, a_2c_2, b_2c_2 and $a_2b_1c_2$, they obtained significant production rates;
- in the case of production stability analysis under drought conditions, the *Romanza F1* hybrid obtained superior results for both calculated indices, the b_2 graduation has a higher drought sensitivity but demonstrates a higher production stability compared to b_1. For factor C graduations, the highest drought tolerance was recorded by C_2, while the highest production stability was obtained at C_3.
- regarding the influence of the three factors on the water content of the fruit of watermelon, the individual factors and their interaction did not significantly affect this characteristic;
- regarding the influence of the three factors on the dry matter content of the fruits, the factors A and C and the interaction of the factors AxC, BxC and AxBxC influenced the value of this characteristic, which was also provided statistically;
- observing the influence of the three factors on the soluble dry matter content of the fruits, both individual and cumulative effects have statistically influenced the value of this index;
- related to the influence of the three factors on the titratable acidity, factors B and C and the interaction of the factors A x C, B x C and A x B x C influenced statistically the value of this index;
- regarding the carbohydrate content, factors A and C and the interaction of factors A x C, B x C and A x B x C influenced statistically the value of this characteristic;
- in the study of the vitamin C content, factors A and C and the interaction of factors AxC, BxC and AxBxC influenced statistically this characteristic;
- the nitrate content of the fruit was calculated through the statistical analysis of factors A and C and the interaction of factors AxC, BxC and AxBxC which influenced this fruit quality indicator;
- in the case of the statistical analysis of the number of fruits/plant, the factors A and C and the interaction of the factors AxC, BxC and AxBxC influenced statistically the value of this index;
- for the average weight of the fruit, all the analyzed factors, as well as their interaction, influenced statistically this indicator;
- the transpiration value analysis was also statistically influenced by all the analysed factors and by their interaction;
- the value analysis of photosynthesis was statistically influenced by factor A and the interaction of AxB and AxBxC factors.

After analyzing the correlations and regressions between the studied characteristics in this experiment, 9 strong links were identified for which regression models based on

either the simple linear equation or the polynomial equation of different degrees can be calculated: total production and no. of fruits/pl., production and photosynthesis, water content of the fruit and total dry matter, water content of the fruit and soluble dry matter, water content of the fruit and the carbohydrate content, total dry matter and soluble dry matter, total dry matter and carbohydrate content, soluble dry matter and carbohydrate content, titratable acidity and nitrate content.

The paper ends with ***General conclusions and recommendations***, which summarize the most important achievements of the present study as it appears from the data presented in the previous parts of the PhD thesis.

The thesis presents elements of originality and chosing this research theme is justified by the necessity of the researches conducted, by the need to find new solutions and methods regarding the improvement of the technological sequences of cultivation of the watermelons in order to increase the economic efficiency of this culture. These aspects can only be achieved by improving some crop technology sequences and adding new ones, which must be verified under the existing conditions of the sandy soils specific to Dăbuleni area and especially in the climatic conditions offered by the Dăbuleni area. Any new features that have been added to the technology of watermelons growing on the Dăbuleni sands - *new cultivars or new planting density* - are welcome and applicable, especially because the species currently has an important share within the crops on this type of soil and tends to extend but also because it is the main occupation of private producers in this area who access European funds through the National Rural Development Plan 2014-2020. The practical aspects studied in this paper represent important milestones in the crop technology of this species and can be recommended for immediate application to direct producers as a niche of ecological adaptation to current topoclimatic conditions.