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The Effect of Climate Change on Medical Aromatic Plant Cultivation

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Abstract – Global warming and climate change have negative impacts in many areas around the world. One of these effects has also been on medicinal aromatic plants, which are used in many fields such as food, pharmacy, cosmetics, paint, agriculture, medicine. They also have an important economic value. Adverse conditions caused by climate change, such as unexpected temperature increases, drought, sudden and excessive rainfall, negatively affect the growth and development of medicinal aromatic plants, as well as their production characteristics. In addition, climate changes can make plants more vulnerable to diseases and pests, leading to a decrease in plant yield, deterioration in quality and the loss of some species. In order to be least affected by this negative situation, medical aromatic plant growers can use methods such as natural resources conservation, soil health, water cycle and carbon footprint, and the way to discover new species that can adapt to the climate type in their regions by using climate-appropriate organic farming techniques required for medical aromatic plant agriculture. In this study, the aim is to draw attention to the value of medicinal aromatic plants for humanity, their economic and commercial importance, growing conditions, the effect of climate change on plant production and possible solutions.

Keywords – Global Warming, Climate Change, Medicinal Aromatic Plants, Organic Farming, Plant Breeding.

I. INTRODUCTION

Agricultural production is an indispensable element for life, which has maintained its importance since the beginning of human history and is shaped according to today's needs. Agricultural production has gained importance due to the transition from nomadic life to settled life and the ever-increasing human population. In the following years, with the development of science and technology, agricultural products have become the source of raw materials not only for food but also for health, textile, energy production, fuel, cosmetics and pharmacy [1].

Medicinal aromatic plants have no special meaning in terms. This name is derived from the combination of the terms medicinal, which means healing, curative, and aromatic plant, which means giving good taste and smell. While medicinal plants are generally used for purposes such as physical and mental health and cosmetics, aromatic plants are used to give flavor to food and to spread a fragrance [2].

According to the World Health Organization (WHO), 'medicinal and aromatic plants are plants used in the field of traditional medicine, which can be used to protect from physiological and psychological diseases, to identify and cure these diseases, as well as to maintain a quality life in terms of health, and can vary among cultures and beliefs [3].According to the data from WHO , the number of medicinal aromatic plants used in the world today is estimated to be around 20 thousand. What makes these plants different from others are volatile and fixed oils, organic acids, alkaloids, tannins, glycosides, antibiotics, vitamins and resinous

compounds found in their compositions. These components, different plant species and drugs obtained from different parts of these plants (leaf, root, stem, fruit, seed, flower) have been used as food, medicine and spices .

Although these plants, which have been used for a long time, grow in nature, some species are cultivated and commercially produced. Species used for medical purposes are generally collected from nature, and cultured species are generally used in the field of food, paint and cosmetics. With the advancement of science and technology, studies have increased, people have found new ways to benefit from plants, and the fields of use of medicinal aromatic plants have increased to serve humanity in many ways[4]. Worldwide usage rates of medicinal aromatic plants vary by years and countries. While this rate was around 80% in developing countries , 95% in underdeveloped countries, and 40-50% in developed countries in 1980s, these rates moved in the opposite direction in the 2000s. The most important commercial centers of these plants in the world are in the USA, Japan, Germany and the UK [5].

The distribution of plants throughout the world is not equal. Variability in climate, soil and weather conditions has made this distribution heterogeneous. Temperate, humid and rainy tropical regions are the richest in terms of plant diversity. The number of species decreases towards the poles and the equator [6]. The highest number of plant species by country is found in the USA, China, India, and this also applies to medicinal aromatic plants. The number of medicinal aromatic plant species in the world is around 5 thousand and the number of species used for commercial purposes is around 3 thousand [7].

Although most of the medicinal aromatic plants grow naturally, there are also plants that are cultivated. Some of the medicinal and aromatic plants widely grown and used in the world and Turkey are: *Humulus lupulus* L. (Hops), *Lavandula spp*. (Lavender), *Rosa spp.* (Rose), *Papaver somniferum* L. (Poppy), *Carthamus* tinctorius L. (Aspir), *Salvia officinalis* L. (Sage), *Dianthus caryophyllus* L. (Clove), *Sesamum indicum* L. (Sesame), *Pimpinella anisum* L. (Anise), *Asparagus spp.* (Asparagus), *Mentha piperita* L. (Mint), *Rosmarinus officinalis* L. (rosemary), Benth. *ex Kurz* (Snake root), *Ocimum sanctum* L. (Sacred Basil, Tulsi), *Coleus forskohlii Briq* [8].

Some medicinal aromatic plants and methods of use are shown in Table 1.

Table 1 Medicinal Aromatic Plants Used in Some Disease Treatments

Disease name	**Plants Used in Therapy**
Hemorrhoids	Yarrow, gallnut, rosehip, ginger, elderwort
Indigestion.	Anise, hawthorn, dill, cardamom, chamomile, cumin, fennel, ginger, allspice
Kidney Disease	Golden grass, twitch grass, horsetail
Cancer	Nettle, mistletoe, red pepper,
Heart Diseases	Mistletoe, hawthorn
Gastrointestinal bleeding	Spud root, mint, ginger
Climacteric	Sage, yarrow, anise, cinnamon, cloves, chamomile
Liver disease	Yarrow, sumac, rosehip
Stomach Pain and Nausea	Artichoke, wolfsbane, endive, turmeric
Gallbladder	Golden grass, endive, yarrow, turmeric, wormwood
Rheumatism	Anise, rosemary, horsetail, lavender, clove, thyme, chamomile, melissa,
Prostate	Curd root, green tea, nettle root, turmeric
Forgetfulness and Memory Weakness	Juniper, echinacea, hibiscus, linden, licorice, clove, mint, chamomile, eucalyptus, ginger
Stress, Depression and Anxiety	Anise, lavender, St. John's wort, melissa, fennel, chamomile, hops
Common cold and Coughs	Sage, cardamom, rosemary, ginger, green tea
Sleep disturbance	Anise, valerian, primrose, melissa, fennel, chamomile, hops
Prostration	Sage, licorice, rosemary, cardamom, rosehip, thyme, ginger

Source: (9)

1) Economic Importance of Medicinal Aromatic Plants

There is no special classification that includes statistics on the economics of medicinal and aromatic plants and their products, whose market

value is increasing day by day, or the effect of climate change on medicinal aromatic plants. The excessive number of species of these plants and the fact that most of them are collected from nature without being recorded prevents such specific study. The most reliable source for data on the commercial volume of medicinal and aromatic plants worldwide is the International Trade Center (UN Comtrade) data bank.The classification system developed by the World Customs Organization (WCO) and used in 180 countries is the "Harmonized Commodity Description and Coding System" HS [15] [16]. The system equivalent of HS, which is accepted by the European Union and widely used in many countries and economies today, is "Customs Cooperation Council Nomenclature" (CCCN) in Turkey [17]. According to the International Trade Center-ITC data; while the export value of medicinal and aromatic plants products worldwide was 48.7 billion dollars in 2001, this value increased to 207.5 billion dollars in 2019 [18]. These data show that the interest in medicinal aromatic plants has increased.

Export values of some medicinal aromatic plants are shown in Table 2.

HS2 Codes	Products	Export Value ($1000)					
		2001	2015	2016	2017	2018	2019
09	Coffee, tea, Paraguay tea, spice	12.B	48.B	48.B	51.B	50.B	48.B
13	Lacquer, gum, resin etc. herbal extract water and extracts	2.B	7.B	7.B	7.B	8.B	8.B
33	Essential oils and resinoids, cosmetics, etc.	34.B	111.B	116.B	130.B	146.B	150.B
	World (Sum)	48.B	166.B	172.B	188.B	204.B	207.B

Table 2. Export values of medicinal aromatic plants between 2001-2019 (billion dollars)
Source. [19].

A. CLİMATE CHANGE

"Climate is known as the average weather that occurs over a very long period of time in large regions. The climate is effective in a wide area and determines the character of a region's weather events and vegetation. Climate change, on the other hand, is the situation where the climate is out of the ordinary and unexpected weather events occur. This change is a growing concern around the world. Cited as the most important cause of climate change is the rising levels of carbon dioxide, methane and other greenhouse gases in the Earth's atmosphere. Greenhouse gases cause an increase in temperature in the atmosphere due to the reflection of the sun's rays after they enter the Earth's atmosphere. This causes unusual effects by affecting the climate systems on the planet [10].

Although the main sign of climate change appears to be the rising temperatures with global warming, there are many other problems such as rising sea levels, extreme weather events, drought, wildfires, melting of glaciers, change of gas balance in the atmosphere . These problems can primarily threaten the life on earth with environmental effects and cause social, economic and environmental effects worldwide [11].

One of the biggest factors causing climate change is the use of fossil fuels. Since industry, transportation, energy production and other sectors are dependent on fossil fuels, they cause the release of carbon dioxide and other greenhouse gases into the atmosphere [12].

1. Changes in temperature

The most prominent feature of climate change is temperature increases. Carbon dioxide (CO_2), known as greenhouse gas accumulated in the atmosphere layer, methane (CH_4), ozone (O3), water vapor (H2O) and nitrogen oxides (NO) occur in increasing amounts due to human activities and cause heat to remain in the atmosphere by keeping the sun's rays in the earth's atmosphere. It is known that this is one of the main reasons for the increase in average temperatures around the world. In recent years, there have been many studies proving that average temperatures around the world have increased, and according to the World Meteorological Organization (WMO) 2021 report, the period

between 2011 and 2020 has been the warmest decade ever recorded [13]. In recent years, when climate change and temperature data are examined, there is evidence that temperatures have increased worldwide. Especially in the last 50 years, it is seen that average temperatures have increased significantly compared to previous centuries [20].

According to a report published by the World Meteorological Organization (WMO), the last 5 years (2016-2020) have been the warmest 5 years ever recorded in world history. Each of these years the average temperatures rose by more than 1.1°C. 2020 was the third warmest year. The increase in population and the energy need it brings, the use of fossil fuels in energy, industrialization, urbanization, deforestation, random use of lands, agriculture and livestock activities and wastes that cause the increase in greenhouse gas emissions such as Methane (CH_4), Carbon Dioxide (CO_2), Diazote Monoxide (N2O) in the atmosphere are considered to be the main reason for the increase in temperature. The following tables show the temperature change andCO_2(ppm) in the atmosphere over the last 50 years [21].

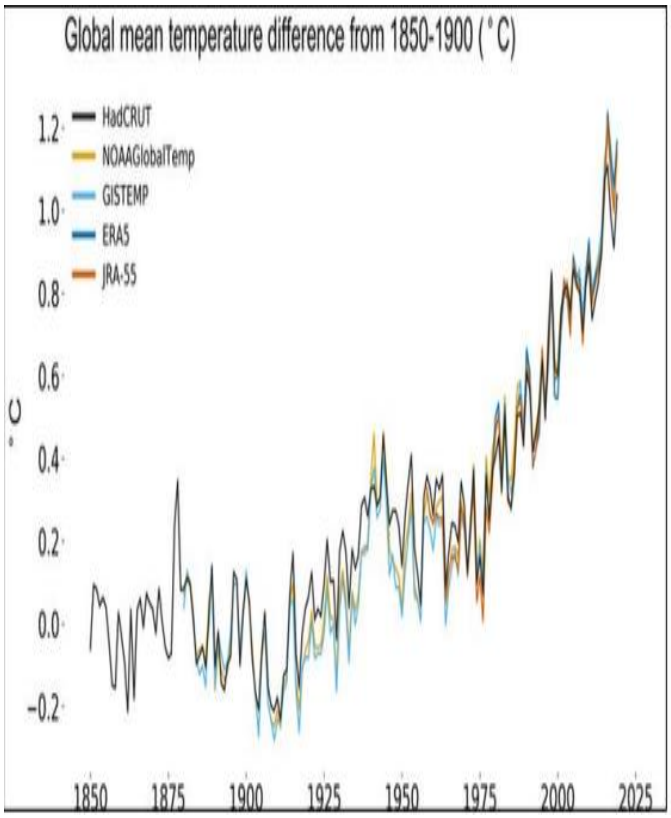

Figure 1. Global average temperature difference between 1850-1900 (ºC).

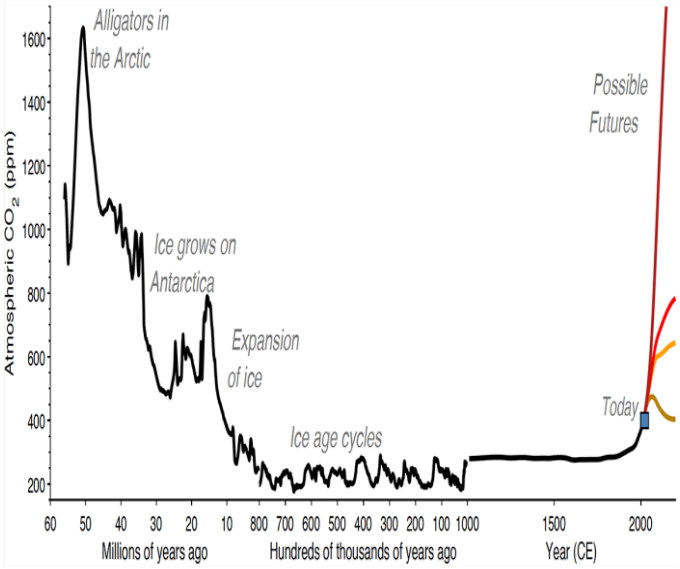

Figure 2. CO_2 (ppm) change in the atmosphere over the last 50 years. Source [22].

2) Precipitation Regime Changes

Precipitation regimes are expressed as the expected amount and distribution of precipitation in a given period in a region. The effect of climate change on the precipitation regime increases the amount of humidity in the atmosphere by increasing the evaporation of vapor with the increase of temperature. Increasing humidity can cause an increase in precipitation. Although this increase seems to be positive, it is a negative situation because the rainfall is excessive, sudden and irregular, the soil flows without being able to hold the water, and causes floods. In addition, climate change may change the distribution of precipitation regimes, especially in dry regions, the intensity of precipitation may decrease and prolonged periods of drought may be more frequent, water resources may decrease, and in tropical regions, the risks of heavy rainfall and flooding may increase due to the increase in the severity of tropical storms and hurricanes [14].

3) Change of Disaster Events

As a result of temperature increases, melting of glaciers and rising sea levels across the globe are the most prominent observations. In addition, temperature increases are thought to be the main reason for the decrease in clean water resources

worldwide, prolonged droughts, deforestation, decrease in agricultural production, increased forest fires, heat waves, hurricanes and other natural disasters [23]. As can be seen in Figure 3, when the reasons for the increase in natural disasters and the events themselves are examined, it is revealed that it is directly proportional to climate change and temperature increase.

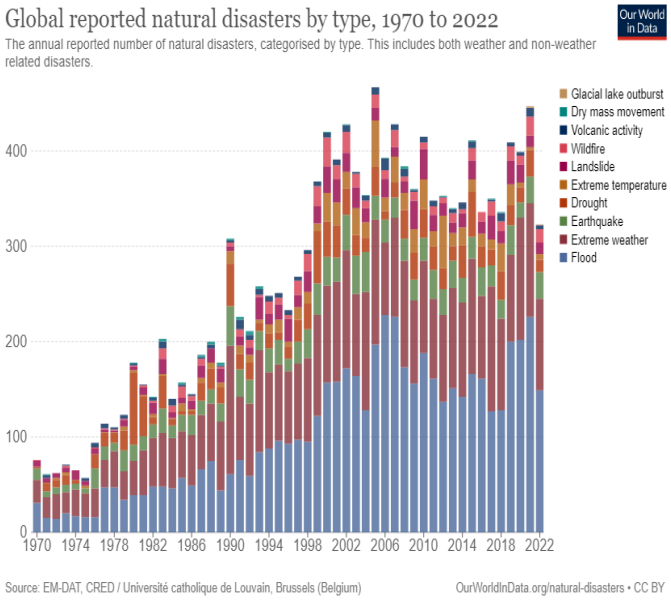

Figure 3. Distribution of worldwide catastrophic events by years in recent years. Source [24].

C. THE RELATIONSHIP BETWEEN MEDICINAL AROMATIC PLANTS AND CLIMATE CHANGE

Medicinal aromatic plants are plants used to treat a variety of health problems and have significant commercial value worldwide. However, it is thought that the cultivation of medicinal aromatic plants may be adversely affected by climate change, in particular, factors such as temperature, precipitation, drought, soil moisture and disease control will adversely affect plant production [25].

One of the most obvious effects of climate change is the rise in temperature. Most medicinal aromatic plants do not tolerate high temperatures and it is predicted that these temperatures will adversely affect plant growth and cause various diseases such as fungal formation in many plants [26]. In particular, it is thought that droughts may reduce plant growth and decrease plant yield, as well as excessive rainfall may spread plant diseases, cause damage to the plant in cases such as erosion and landslide, and changes in soil moisture due to excessive rainfall or drought may cause changes in the amount of medicinal aromatic plant content and affect the quality characteristics of the plant [27]. In a study, it is predicted that in 2100, if countries around the world do not take any measures, the amount of CO_2 emissions will increase to around 160 ppm and the average temperature will increase in the° range of 4.1-4.8 C [28].

The following measures can be taken to prevent or minimize the impact of climate change on medicinal aromatic plants.

1. *Improved Irrigation Methods*

Farmers can be provided with appropriate training on how much and when a plant needs water. Instead of traditional irrigation, water-saving methods such as drip irrigation and rainwater can be utilized more efficiently [29].

2. *Diversified Production*

The production of different types of medicinal aromatic plants and the orientation to different varieties instead of a single product can provide a more resistant production against the negative effects that may otherwise be experienced [30].

3. *Use of Climate Change Resistant Plant Species*

The use of climate change-resistant and less water-consuming plant species can make plants more resistant to adverse conditions such as drought and high temperatures [31].

4. *Measures Against Disasters*

Necessary precautions should be taken against the disasters. Every hazardous situation during the period between field planting and harvest time should be examined and necessary measures should be taken.

In addition to all these, climate change should be turned into a state policy, growers should be given the necessary training and the necessary financial support should be provided [32].

2. RESULTS

As a result, the effects of global warming and climate change, which are among the most important environmental problems in recent years, affect human beings and all living things. It is obvious that climate change will have negative effects on medical aromatic plant cultivation, which is used in many areas and has an important economic value throughout the world. Despite all these negativity, it is thought that taking the necessary precautions and taking all the right steps will help minimize the damage.

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