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Review article

Effects of Different Rainfall Regimes on Soil Plant Ecosystems and Preventable Adaptation Processes

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Abstract

The purpose of this review paper is to provide an overview of the global impacts on soil properties, crop production and water resources of variations in precipitation regimes as a result of climate change and to briefly summarize possible sustainable measures/adaptation processes to minimize risk. Extreme temperatures and extreme precipitation are expected to increase in the coming years due to global warming. As a matter of fact, one of the negative impacts of climate change is the "change in the intensity and distribution of precipitation". In fact, precipitation that should fall in a few months can fall on the earth in a few hours, causing significant damages and damages. Probably no other factor causes the deterioration of soil fertility as much as rainfall, either in the short term or over the ages. The pain of rainfall is felt mainly in the soil and its effects are far-reaching. It significantly increases the need for fertilizer. Agricultural authorities and farmers, who think about economics in all matters, do not think about the fact that rainfall, which is instrumental in changing soil nutrient levels, is a major disruptor of the soil nutrient economy.

In water management, as in all agricultural activities, the evolution of technology has revolutionized modern farming, but it is questionable how useful it can be for managing water. "It is essential that we do our best in water management, using all the tools we have." Precision agriculture technology will certainly play an important role in this regard, but which tools will provide farmers with the most accurate and valuable information for water management will depend on soil and climatic conditions.

Keywords: Rainfall Regime, Soil Properties, Crop Response, Climate Change.

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INTRODUCTION

About 97.5% of the world's water is salt water, found in seas and oceans. Fresh water accounts for only 2.5%. 68.6% of this fresh water is in the form of ice and permanent snow cover in the Arctic, Antarctic and mountain glaciers. 30.1% is fresh groundwater. Only 0.3% of the world's freshwater is in easily accessible lakes, reservoirs and river systems (Gleick, 1993). Globally, changes in water, atmospheric vapor content, cloud cover and ice affect the Earth's radiative balance and thus play an important role in determining the climate response to increasing greenhouse gas emissions (Bates et al., 2008). For example, in 1955, only seven countries were in water stress conditions. This number increased to 20 in 1990 and 10-15 more countries will be added to this list by 2025. It is also estimated that by 2050, 2/3 of the world's population will be in surface water stress conditions (Gosain et al., 2006; Daba et al., 2018).

Global warming is increasing the evaporation of water into the atmosphere and altering patterns of large-scale climate changes, such as El Niño and La Niña weather patterns and ocean currents. This in turn alters the distribution of precipitation, so that some regions are exposed to more rainfall and flooding, while others are more prone to drought. In recent years, the study of the impacts of climate change on the quantity and quality of water resources has received considerable attention, particularly at regional and global scales (IPCC, 2014). The most recent report by the Intergovernmental Panel on Climate Change (IPCC) found that the average global temperature will increase by between 1.1 and 6.4°C between 2090 and 2099 compared to temperatures between 1980 and 1999, with the most likely increase being between 1.8 and 4.0°C. The most dominant climate drivers for water availability are precipitation, temperature and evaporative demand (net radiation at the earth's surface, atmospheric humidity and wind speed and temperature). Changes in climate will have impacts on the environment, including soils (Brevik, 2012).

Soils are also important for food security (Lal, 2010; Blum & Nortcliff, 2013 & Brevik, 2013) and climate change has the potential to threaten food security through its impacts on soil properties and processes (Brevik, 2012). Changes in precipitation and temperature have a direct impact on the amount of evaporation and the quantity and quality of surface runoff. Numerous scientists have reported that climate change affects the hydrological cycle or water cycle components, particularly precipitation, evaporation, temperature, streamflow, groundwater and surface runoff. A change in climate can alter the spatial and temporal availability of land and water resources. These changes will cause increased flooding and drought, which will have significant impacts on the availability of soil and water resources. Soils are intricately linked to the climate system through nitrogen, carbon and hydrological cycles. Changes in climate will affect soil processes and properties. Climate change, together with changes in temperature, will lead to changes in global rainfall amounts and distribution patterns. Since temperature and water are two factors that have a major impact on the processes that take place in soils, it is therefore likely that climate change will cause changes in the world's soils (Daba et al., 2018).

The place and importance of water in agriculture

Soil water is one of the most important substances that affect physical, chemical and biological events in the soil. We can list these effects as follows:

a- It meets the water needs of plants. Water is a direct plant nutrient.

b- It is a necessary environmental factor for microbial activity.

c- It is an environment that decomposes the nutrients it contains into ions and molecules for plants and microorganisms and makes them ready for plant use.

d- The heat capacity, thermal conductivity and heat absorption of soils vary with the amount of water in the soil.

e- It is an important factor in the occurrence of chemical reactions in the soil (especially on the inner and outer surface of soil particles).

f- It provides the transportation of substances dissolved in water. Thus, it ensures that excess salts or pollutants are washed into the groundwater.

g- It affects the physical properties of the soil (Yıldız, 2012).

The water balance of the soil depends on the following factors:

1- Effective precipitation; water that can be stopped by vegetation.

2- Surface runoff; depends on topographical factors.

3- The water holding capacity of the soil varies depending on percolation.

4- Transpiration; Removal of water from the surface of plant leaves (transpiration).

5. Evaporation; Removal of water from the soil surface (Yıldız, 2012).

Definition of precipitation as a concept

Precipitation is a term used for all forms of moisture falling towards the ground, including snow, drizzle, hail, ice particles and their various forms. In other words, the term precipitation is used for any form of water in liquid or solid form that falls from the clouds and reaches the ground. While the amount of precipitation measured for a certain period in many countries is given in inches, in the meteorology of our country it is measured in millimeters and expressed in kilograms per square meter. In hydrology, precipitation is used to mean the mass that falls to the earth as liquid and solid formed by the combination of water vapor in the atmosphere. Most of the precipitation is formed by water evaporating from the oceans and seas (Günel, 2005)

Precipitation falls on the earth in different forms and characteristics depending on the region. Some precipitation starts fast and ends slowly, while others start strongly and fade over a long period of time. The curves that classify and describe these characters according to regions are called rainfall frequency curves. Precipitation frequency also refers to the distribution of precipitation over time. Precipitation frequency curves show how precipitation has fallen or will fall in a region in 50 or 100 years (Günel, 2005).

Turkey's Water Resources

Water resources available in Turkey are directly related to precipitation regimes. Turkey is a country with a semi-arid climate. Although the precipitation regime in the country shows regional differences depending on climatic and seasonal characteristics, the average annual precipitation is 574 mm and the annual precipitation is calculated as 450 billion m^3. There are 25 river basins in Turkey. The reasons such as the variability of precipitation in the country according to seasons and regions and the differences in the bed slopes of the rivers cause the flow rates/regimes of the rivers, the amount of water and load they carry and their erosion powers to vary throughout the year. On the other hand, there are 320 natural lakes in the country. Some of these lakes are seasonal in nature, filling up with winter precipitation and drying up in the summer when precipitation decreases or is absent. The number of dams in operation in Turkey is 861 (DSİ, 2022; Taşkın et al., 2022).

When Turkey's water potential is analyzed, it is seen that the annual surface runoff is 186 billion m^3 and the available surface water is 94 billion m^3. In addition, the annual amount of withdrawable water in the groundwater potential in the country is 18 billion m^3, while the total amount of usable water (net) is 112 billion m^3. Total water use in the country is 57 billion m^3. According to estimates, total water use in the country will be 112.0 billion in 2023 (TSKB, 2019). Within the available water potential (77%), irrigation water use has the highest share with 44 billion m^3. The remaining 13 billion m^3 is used as drinking, domestic and industrial water (DSİ, 2021; Taşkın et al., 2022).

According to the water footprint analysis used to determine the use and consumption of water, the highest share of the water footprint of production in Turkey belongs to agriculture with a share of 89%, 7% to domestic use and 4% to industrial use. Of the water footprint of agricultural activities, 92% comes from crop production and 8% from grazing. Looking at the water footprint of crop production, cereals have the largest share with 38%. Cereals are followed by fodder crops with 32%, fruits/hard-shelled fruits with 13%, industrial crops with 10%, oil crops with 5% and vegetables/legumes with 2% (WWF, 2014).

Water resources are the world's main source of life. One of the most important consequences of climate change, perhaps even the most important one, is its negative impacts on water resources. It has been proven in all scientific reports that the most important impact of climate change will be on the water cycle. Studies reveal that more than 3 billion people will experience water scarcity as of 2025 (Taşkın et al., 2022).

The report published by the General Directorate of Agricultural Reform of the Ministry of Agriculture and Forestry states that while determining the short and medium-term agricultural policies for Turkey, a temperature increase of 2-3 degrees and the effects of this increase on the climate are considered as a hypothetical scenario. When it comes to the effects of climate change on the water cycle, a much more pessimistic picture emerges. The report states that the total amount of usable water in Turkey is 112 billion cubic meters, including 98 billion cubic meters of surface water and 14 billion cubic meters of groundwater, and emphasizes that “we are not a water-rich country and even under water stress”: “The irrigation rate is 65 percent and the irrigation efficiency is 45 percent in the areas opened to irrigation throughout the country. Moreover, considering that 15 tons of water is needed for 71 kg of meat and 170 kg of water is needed for 1 cup of coffee, sustainable management of water resources becomes more important.”

In the report, where the practices and recommendations to be made in the short and long term regarding adaptation and mitigation to climate change are shared separately, some of the short-term measures are listed as follows:

- An action plan for adaptation to climate change in the agriculture sector will be developed and studies will be carried out to make the existing adaptation actions more applicable.
- Agricultural drought early warning systems will be established for agricultural and pasture areas within the scope of “Turkey's Strategy and Action Plan for Combating Agricultural Drought”.
- National Land Use Planning will be realized.
- An ecosystem-oriented food production model will be established (Anonymous, 2021)

Due to climate change:

- Changes in the water cycle (increased atmospheric water vapor, change in precipitation regime, extreme consequences such as droughts and floods, extensive melting of mountain glaciers, glacier cover blocking water accessibility during dry periods, changes in soil moisture)
- High air temperatures affect water quality
- Sea level rise leads to salinization of estuarine and coastal groundwater, reducing access to freshwater for people and ecosystems in coastal areas.

Heavy Rainfall

One of the negative impacts of climate change is the change in the intensity and distribution of precipitation. Precipitation that should fall in a few months can fall in a few hours, causing serious damages. A significant decrease in precipitation is expected in the Western and Southern regions, where the Mediterranean climate prevails, while precipitation is expected to increase in the Black Sea Region, where a moderate mid-latitude climate prevails. Due to increasing temperature and decreasing precipitation, an increase in the severity, frequency and duration of drought events is expected (Anonymous, 2022)

Approaches to the effects of climate change and changes in precipitation regime on soil ecosystems “from past to present”

We are in a period in which the natural balance of our planet, the only planet on which we are directly and indirectly dependent for the provision of our living conditions and on which there is no alternative or substitute, has been disrupted by human (anthropogenic) actions and the negative effects of these disruptions are gradually increasing. The limits of the negative impacts of climate change are uncertain and if we ignore these negative impacts and do not take the necessary precautions and adaptation efforts, we, human beings, will pay for the negative impacts and it will become difficult to control. Plants, which are of vital importance for all living things on the earth's surface, are likely to experience increased mortality, migration or adaptation requirements in the future as a result of geographical variability of parameters such as temperature and precipitation due to climate change.

Expected changes in temperature, especially precipitation, as a result of global warming are subject to large uncertainties for several reasons. For example, increases in plant growth rates or water use efficiency due to increases in atmospheric CO_2, sea level rise, increases or decreases in climate-induced vegetation cover or changes in farmer's options, and changes in soils due to anthropogenic impacts, indirect effects of climate change on soils, Brinkman and Sombroek (1996), who mentioned that higher temperatures or greater precipitation variability and larger or smaller precipitation totals could have much greater direct effects on soils than the direct effects of higher temperatures or greater precipitation variability and larger or smaller precipitation totals on soils, hypothesized that the following possible changes in the ecological environment, forcing variables, were likely to occur within the next century as a result of climate change or global warming:

A gradual and continuous increase in CO_2 concentration requires increased photosynthesis rates and water use efficiency of vegetation and crops, thus increasing the supply of organic matter to the soil.

A gradual and continuous increase in CO_2 concentration requires increased photosynthesis rates and water use efficiency of vegetation and crops, thus increasing the supply of organic matter to the soil.

- Small increases in soil temperatures in the tropics and subtropics, moderate increases in temperate and cold climates where soils are sufficiently warm (warmer than about 5°C) for microbial activity, and long periods parallel the changes in air temperatures and vegetation zones summarized by Emanuel et al. (1985).

-Small increases in evaporation in the tropics and large increases at high latitudes due to both temperature increase and prolongation of the growing period.

- Increases in precipitation amount and variability in the tropics; possible decrease in precipitation in a band in the subtropics towards the poles of existing deserts; small increases in amount and variability in temperate and cold regions. Peak rainfall intensities may increase in a few regions.

- Gradual sea level rise leading to deeper and longer-lasting inundation in river and estuary basins and on embankment slopes, and flooding leading to the spread of vegetation causing pyrite deposition in near-shore soils. Higher atmospheric CO_2 concentration increases growth rates and water use efficiency of crops and natural vegetation, unless other factors become limiting. There will be sufficient time to adapt to the changes because they are expected to take place over decades rather than years or days as in all current experimental situations (Brinkman and Sombroek, 1996).

Effects of elevated CO_2 on soil fertility, physical conditions and productivity

Higher atmospheric CO_2 concentration increases growth rates and water use efficiency of crops and natural vegetation, unless other factors become limiting. The higher temperature optima of some plants under increased CO_2 will tend to offset the negative effects of temperature increase, such as increased nocturnal respiration. Increased productivity is usually accompanied by more litter or crop residues, greater total root mass and root exudation, increased mycorrhizal colonization and activity of other rhizosphere or soil microorganisms, including symbiotic and root zone N fixers.

The latter will have a positive effect on N supply to crops or vegetation. Increased microbial and root activity in soil means higher CO_2 partial pressure in soil air and CO_2 activity in soil water, hence increased rates of plant nutrient release (e.g. K, Mg, micronutrients) from the erosion of soil minerals. Greater microbial activity tends to increase the amount of plant nutrients circulating among soil organisms. Increased production of root material (at similar temperatures) tends to increase soil organic matter content, which requires the temporary immobilization and circulation of greater amounts of plant nutrients in the soil. Higher C/N ratios in litter, reported by some workers under high CO_2 conditions, require slower decomposition and slower remobilization of plant nutrients from litter and uptake by the root mat, allowing more time for incorporation into the soil by earthworms, termites, etc. Higher soil temperatures offset increases in 'stable' soil organic matter content, but further stimulate microbial activity.

In all experimental situations, whether room or free-air enrichment, CO_2 increases are rapid or sudden, often doubling the ambient concentration, sometimes higher. The resulting rapid increases in soil organic matter dynamics and soil microorganisms can cause temporary competition for plant nutrients. These transient effects have occasionally been reported as negative factors affecting plant response to increased CO_2. However, when CO_2 concentrations increase gradually over decades, as they are now and have done in the recent past, increased organic matter dynamics and microbial activity in soils are favorable for the soil-plant system. Future experiments could be arranged to compensate for transient effects due to the abruptness of the CO_2 increase, for example with artificially higher soil organic matter contents estimated to be close to equilibrium with each gradually higher CO_2 concentration, higher CO_2 concentration in the range 350 to 600 ppm, and increased microbial activity due to temperature-dependent increased microbial activity producing greater amounts of polysaccharides and other soil stabilizers.

Increases in litter or crop residues, root mass and organic matter content tend to stimulate the activity of soil macrofauna, including earthworms, resulting in improved infiltration rate and bypass flow by a greater number of stable biopores. Greater stability and faster infiltration increases soil resilience to water erosion and the consequent loss of soil fertility. The increased rate of bypass flow also reduces nutrient loss through leaching during periods of excessive rainfall. This refers to nutrients available in the soil, including well-mixed fertilizers or animal manure, but not fertilizers spread on the soil surface. These are lost through surface runoff or leaching. These changes increase the resilience of the soil to physical degradation and nutrient loss due to increased intensity, seasonality or variability of rainfall; they also increase its resilience to some of the adverse changes in the rate or direction of soil-building processes discussed in subsequent chapters. Some of these benefits are not realized if the partial pressure of CO_2 in the soil air increases and the pressure of O_2 decreases to levels that impair root function. Improved gas exchange with the atmosphere through an increasing number of stable biopores will tend to keep CO_2 and O_2 in the soil at 'safe' levels, at least in naturally or artificially well-drained soils. wetland plants such as paddy have their own gas exchange mechanisms and are not affected; neither is natural wetland vegetation. The positive effect on decomposition rate and nutrient availability will occur in soils with significant amounts of decomposable minerals, not in soils that are too deep and severely weathered or otherwise too poor (Brinkman &Sombroek, 1996).

In humid tropics and monsoon climates, the increased intensity of rainfall events and increased rainfall totals will increase infiltration rates in well-drained soils with high infiltration rates and cause temporary inundation or water saturation of many soils in flat or depressed areas, thus reducing organic matter decomposition. This could affect a significant proportion of particularly good soils, for example in Sub-Saharan Africa. It will also result in greater amounts and frequencies of runoff on soils on sloping terrains, sedimentation will be downslope and worse downstream (Brinkman &Sombroek, 1996).

In subtropical and other semi-humid or semi-arid areas, increased productivity and water use efficiency due to higher CO_2 will tend to increase soil cover, offsetting the effects of higher temperatures. If locally there is much less rainfall and increased annual and inter-annual variability, these can lead to less dry matter production and hence lower soil organic matter content in due course. Periodic infiltration during high-intensity rainfall with less vegetation cover can desalinate some soils in well-drained areas, cause increased runoff in others, and lead to soil salinization in depression areas or where the groundwater level is high. The soils most resilient to the effects of such increased drought and rainfall variability will have high structural stability and a strongly heterogeneous macropore system (the same as in the tropics), hence a rapid infiltration rate, as well as a large available water capacity and a deep groundwater level. Higher temperatures, especially in arid conditions, bring higher evaporation demand. This can lead to soil salinization if, for example, there is sufficient soil moisture in irrigated areas, but land or farm water management or irrigation scheduling or drainage is inadequate. On the other hand, recent experiments from the Salinity Laboratory in Riverside, California, show that salt tolerance of crops increases under high atmospheric CO_2 conditions (Bowman & Strain, 1987).

In temperate climates, small increases in precipitation totals are expected to be largely covered by increased evapotranspiration of vegetation or crops at expected higher temperatures, so that net hydrological or chemical impacts on soils may be small. The negative impact of temperature increase on soil organic matter contents may be more than compensated by a greater supply of organic matter from stronger growing vegetation or crops due to higher photosynthesis, higher potential evaporation-transpiration and higher water use efficiency in a high CO_2 atmosphere. The most resilient soils to impacts such as nutrient leaching and periodic soil depletion will have similar characteristics to the most resilient soils in other climates: sufficient cation exchange capacity and anion sorption to minimize nutrient loss during infiltration flows, high structural stability, and a strongly heterogeneous continuous macropore system to maximize rapid bypass flow during periods of excessive meltwater (Brinkman & Sombroek, 1996).

Processes in soils

The most rapid processes of chemical or mineralogical change under changing external conditions will be loss of salt and nutrient cations, where leaching increases, and salinization, where net upward water movement occurs due to increased evaporation or decreased rainfall or irrigation water supply. The clay mineral composition and mineralogy of the coarser fractions will generally change little even over centuries. Exceptions would be the transformation of X-ray amorphous material into the clay mineral halloysite when a volcanic soil previously under continuously moist conditions is subjected to periodic drying, or the gradual dewatering of goethite to hematite in soils subjected to higher temperatures or severe drying, or both. Changes in the surface properties of the clay fraction, although generally slower than salt movement, can occur much more rapidly than changes in bulk composition or crystal structure. Such surface changes have a dominant influence on the physical and chemical properties of the soil (Brinkman, 1985, 1990).

Changes in the clay mineral surfaces of soils or in the bulk composition of the clay fraction occur through a small number of transformation processes listed below (Brinkman, 1982). Each of these processes can be accelerated or inhibited by changes in external conditions due to global change.

Hydrolysis and waterlogging can be accelerated by increasing infiltration rates. Ferrolysis can occur where soils are subject to alternating reduction by oxidation and leaching: in a warmer world, this could occur over larger areas than at present, especially at high latitudes and in monsoon climates. Dissolution by strong acids occurs, for example, where sulphurous materials on coastal plains are oxidized by improved drainage; however, a rise in sea level makes it less likely to occur naturally. Reverse erosion can begin in areas that became dry during global warming and continues in most areas that are currently arid. These processes will only affect the surface properties of the clay fraction over a period of centuries, even with projected changes as a result of global warming. In contrast, direct human action can greatly accelerate some of these processes, as seen, for example, from the severe effects of acid rain on sandy soils in parts of Europe or the extremely rapid ferrolysis of soils seasonally flooded by water level fluctuations in Lake Volta in Ghana (Amatekpor, 1989).

Not only the rate of soil formation can be accelerated by human action, but also, much more locally, its nature or direction. In most places, natural soil-forming processes are basically unchanged, but there are certain threshold situations, often on fragile soils, where even a small change in external conditions can cause a large and adverse change from one dominant soil-forming process to another. The four examples summarized below (from Sombroek, 1990) An increase in effective precipitation due to climate change could result in a large increase in the extent of Podzols, consisting of yellowish sandy Ferralsols, where Podzols are found today in the area of Ferralsols (Lucas et al., 1987; Dubroeucq & Volkoff, 1988).

Loamy Plinthosols with imperfect drainage in the flat streams of the western Amazon will become shallow, arid soils with an irreversibly hardened subsoil if subjected to drying out with climate change. Dark reddish, porous loamy-clay Ferralsols in the transition zones between forest and savanna in East Africa are stable under existing vegetation, and a denser subsoil with washed clay may form under an unstable topsoil with little organic matter, as was observed where land was cleared several decades ago; the same may occur over larger areas under sparser vegetation brought about by a slightly drier climate.

Silty Fluvisols in the broad river valleys of the Sudan-Sahelian region of West Africa, such as the inner delta of the Niger River, can become saline or sodic with even the slightest change in rainfall and flood regimes- the same soil-hydrological effects of modern-day human actions (Sombroek & Zonneveld, 1971).

The most resistant soils to degradation under conditions of increased rainfall variability and high intensity rainfall frequency have similar characteristics to those resistant to the negative effects of other disturbances: high infiltration rate, high structural stability and persistent heterogeneous tubular macropore system, good external drainage.

Soil reaction (pH)

Most soils are not subject to rapid pH changes resulting from climate change. Exceptions can be found in potentially acid sulphate soils common in some coastal plains and estuaries, if they are subjected to increasingly prolonged dry seasons. Although most such soils are clay with medium or high cation exchange capacity, the amounts of acid released upon oxidation in such soils often exceed this rapid buffering capacity. Therefore, pH values may temporarily reach 2.5 to 3.5 and a small fraction of the clay fraction may decompose. This then buffers the pH in the long term, usually between 3.5 and 4. Depending on how efficiently the excess acid formed can leach out, the period of excess acidity and aluminum toxicity can last from less than a year to several decades.

In calcareous soils, the soil reaction can vary between about 8.5 and 7, depending on the partial pressure of CO_2 in the soil, a range maintained against leaching of essential cations by different soil processes as long as a few percentages of finely dispersed lime remain. Buffering in lime-free soils is less strong, but depends on the cation exchange capacity at soil pH. In soils with variably charged surfaces of the clay fraction, this decreases with acidification. It should be noted that simple modeling of accelerated $CaCO_3$ leaching under doubled atmospheric CO_2 concentration is often not accurate. In most soils, the ongoing decomposition of organic matter keeps CO_2 concentrations in soil air well above the atmospheric concentration even now, and $CaCO_3$ solubility is determined by the partial pressure of CO_2 in soil air and its activity in soil water rather than in the atmosphere. Thus, leaching of lime is positively related to the rate of decomposition of organic matter, negatively related to the rate of gas diffusion and positively related to the amount of water leached from the soil.

Under conditions where leaching is accelerated by climate change, it would be possible to find relatively rapid soil acidification with little apparent change after a long period of time, as is the case with some soils in Europe that have been exposed to acid rain for several decades- but after a shorter latent period. The soil may in fact be permanently depleted of essential cations, but a pH shift can start or become more rapid when certain buffer pools are almost exhausted.

The effects of rising sea levels on land in coastal areas

The likely effects of a gradual eustatic rise in sea level on soil properties will vary from place to place, depending on a range of local and external factors and the interactions between them (Brammer & Brinkman, 1990). In principle, a rising sea level would tend to erode existing coastlines and move them backwards. However, the extent to which this actually happens will depend on elevation, the resilience of local coastal materials, the degree to which they are defended by sediments supplied by river flow or shoreline drift, the strength of shoreline currents and storm waves, and human interventions that can prevent or accelerate erosion. In large deltas, such as the Ganges-Brahmaputra and the great Chinese rivers, sediment supplies delivered to estuaries will usually be sufficient to compensate for the effects of rising sea level. However, such deltaic accretion can be reduced under three conditions:

- Human interventions, such as large dams or successful soil conservation programs, significantly reduce inland sediment supply to the delta: for example, the construction of the Aswan high dam in 1964 led to coastal erosion and increased flooding of lagoon margins in the Nile delta (Stanley, 1988)

- Where the construction of levees within the delta has interrupted the supply of sediment to adjacent marshes and caused them to be inundated by sea level rise: for example, levees along the lower reaches of the Mississippi River have interrupted the supply of sediment to adjacent wetlands, which compensates for soil subsidence due to compaction of underlying sediments (Day & Templet, 1989); - Places where land subsidence occurs due to the withdrawal of water, gas or oil: for example, as is currently happening in Bangkok and the northern part of the Netherlands.

On coastal plains that are not sufficiently defended by sedimentary springs or embankments, tidal flooding by saline water will tend to penetrate further inland than is currently the case, continuously or seasonally expanding the area of saline soils. Where Rhizophora mangrove or Phragmites vegetation invades the area, this will lead to the formation of potential acid sulphate soils over several decades. The blocking of overland drainage by higher sea level and the associated higher levels of adjacent estuarine rivers and embankments will also expand the area of permanently or seasonally diminishing soils and increase the depths and durations of normal flooding in river and estuary basins and on embankment ridges. In areas that become permanently wet, soil organic matter contents will tend to increase, eventually leading to peat formation. On the other hand, when coastal erosion removes the existing barrier of mineral soils or mangrove forests, higher storm surges associated with rising sea level may allow seawater to destroy existing coastal eustatic peat marshes, which may eventually be replaced by freshwater or saltwater lagoons. The likely response of low-elevation coastal zones to sea-level rise can be estimated in more detail based on geologic and historical evidence of changes that occurred in past periods when sea level rose eustatically or in response to tectonic or isostatic movements: e.g., around the southern North Sea (Jelgersma, 1988); in the Nile delta (Stanley, 1988); in the coastal plain of Guyana (Brinkman and Pons, 1968); in the Musi delta of Sumatra (Brinkman, 1987). Contemporary evidence exists in areas where land levels have fallen as a result of recent withdrawals of water, gas or oil from sediments beneath coastal plains. Further study of such contemporary and paleoenvironments, together with location-specific studies, is needed to better understand the processes of change, identify appropriate responses and assess their technical, ecological and socioeconomic impacts (e.g. Warrick & Farmer, 1990). In summary, some of the large and widespread soil changes expected as a result of global change are positive, especially the gradual increases in soil fertility and physical properties due to the increase in atmospheric CO_2. Increased productivity and water use efficiency of crops and vegetation, and generally similar or slightly higher precipitation indicated by several global circulation models, are expected to lead to widespread increases in soil cover and hence better protection against runoff and erosion, although not fully offset by higher evaporation.

Where permafrost will disappear, large but less widespread soil changes are expected, including greater biological activity and increased extent of periodic reduction in soils. In unprotected low-lying coastal areas, the gradual spread of Rhizophora mangroves or Phragmites following more extensive brackish flooding could lead to the formation of potential acid sulphate soil layers after several decades. Deeper and more prolonged flooding of catchments and embankment ridge slopes in adjacent river and estuarine lowlands could lead to more extensive reducing conditions and increased organic matter contents and peat formation locally. Other changes resulting from climate change (temperature and precipitation) are expected to be relatively well buffered by the mineral composition, organic matter content or structural stability of many soils. However, reductions in vegetation cover or annual or perennial crops resulting from locally large precipitation declines that are not compensated for by CO_2 effects can lead to degradation of soil structure and reduced porosity, as well as increased runoff and erosion on sloping areas and accompanying more extensive and rapid sedimentation. Changes in the choices available to land users due to climate change can have similar effects. On some fragile soils, the nature of the dominant soil formation process may worsen as seasonal rainfall increases, decreases or becomes more intense. In most cases, changes in soils, whether in situ or not (intentional or unintentional), by direct human action, are much larger than direct climate-induced impacts. Therefore, soil management measures designed to optimize the sustainable productive capacity of the soil will often be sufficient to counter the degradation of agricultural land due to climate change. Other lands with low-intensity management, such as soils of natural areas or semi-natural forests used for the extraction of wood and other products, are less protected against the impacts of climate change, but such soils are also less threatened by climate change than by human actions that are either out of place, such as contamination by acid deposition, or in place, such as excessive nutrient extraction in very low-input agriculture.

The best that land users can do to protect the world's soils against the negative impacts of climate change or other extremes in external conditions, such as nutrient deficiency or excess (pollution) or drought or heavy rainfall, is to- Manage their soils to ensure maximum physical resilience with a stable, heterogeneous pore system, maintaining as closed a soil cover as possible;

- Using an integrated nutrient management system to balance the input and uptake of nutrients over a cropping cycle or over many years, while keeping soil nutrient levels low enough to minimize losses and high enough to meet occasional high demands.

A similar philosophy can be formulated for large areas of grasslands and production forests, whether planted or managed natural forest, at lower levels of external inputs.

Human action and management are emphasized in these conclusions because much of the world's land is not under natural conditions, but is being used and managed to varying extents (Brinkman & Sombroek, 1996)

According to the scenarios put forward by the United Nations Intergovernmental Panel on Climate Change (IPCC), there will be an average increase of 1-3.5 °C in global temperature by 2100 (Öztürk, 2002; IPCC, 201). In his book published in 2011, Maslin (2011) stated that by 2100, this temperature increase will be around 1.4 °C to 5.8 °C according to different climate models of the IPCC. In the Stern Report (Stern, 2006) It is stated that if the CO_2 concentration exceeds 750 ppm, the temperature may rise 5 °C above the pre-industrial period. This temperature increase will cause a wide range of disastrous consequences such as sea level rise, changes in temperature/rainfall regimes, floods, floods, drought, desertification and biological epidemics. These problems will spread to wider areas and will be seen much more frequently in the future (Öztürk, 2002; Aydın & Sarptaş, 2018). There is a strong scientific consensus that the Earth's climate is changing and will continue to change as human activities increase greenhouse gas concentrations in the atmosphere. The world's population is growing every day and at the same time land and water resources are under threat from natural resource degradation and climate change. The latest IPCC report has made it clear that warming of the climate system is certain and that it is very likely to be caused by "natural and human activities". Numerous scientists have reported that climate change affects the hydrological cycle or water cycle components, particularly precipitation, evaporation, temperature, streamflow, groundwater and surface runoff. A change in climate can alter the spatial and temporal availability of land and water resources. These changes will result in increased flooding and drought, which will have significant impacts on the availability of soil and water resources. Soils are intricately linked to the climate system through nitrogen, carbon and hydrological cycles. Changes in climate will affect soil processes and properties. Climate change, together with changes in temperature, will lead to changes in global rainfall amounts and distribution patterns. As temperature and water are two factors that have a major impact on the processes taking place in soils, climate change will therefore cause changes in the world's soils. To a certain extent, water resources management can help offset the impacts of climate change on streamflow and water availability (Daba et al., 2018).

Impact on Soil Fertility and Nutrient Availability

A European study claims that soil carbon loss is more sensitive to climate change than carbon dioxide. Soil carbon loss was found to decrease in drier regions but increase in wetter regions. This could result in a positive feedback to the atmosphere, which could lead to a further increase in atmospheric CO_2. The authors showed that soil carbon loss was most responsive to change in soil water. Soil water plays a critical role in wet soils where water limits decomposition processes by soil biota resulting in the accumulation of soil carbon as peat. Drying the soil removes this limitation, resulting in the loss of soil carbon loss. Soils are tightly linked to the climate system through nitrogen, carbon and hydrological cycles. Changes in climate will therefore have an impact on soil processes and properties. Soil organic matter levels responding to changes in carbon and nitrogen cycles will affect the soil's ability to support crop growth, with important consequences for food security. Therefore, further study of soil-climate interactions in a changing world is critical to addressing future food security concerns in the nitrogen cycle (Brevik, 2013).

Soils are integral parts of several global nutrient cycles. The two most important for soils and climate change interactions are the carbon and nitrogen cycles because C and N are important components of soil organic matter (Brady & Weil, 2008) and carbon dioxide (CO_2), methane (CH_4) and nitrous oxides oxide (N_2O) are the most important of the long-lived greenhouse gases (Hansen et al, The global carbon and nitrogen cycles were in equilibrium where inputs were approximately equal to outputs during the industrial revolution, when low levels of population and technology minimized the human-induced generation of greenhouse gases, but through the burning of fossil fuels, cultivation of land and other human activities, the natural balance has become such that we now release more carbon and nitrogen into the atmosphere each year than is taken up by global sinks (Pierzynski, 2009). Human management of soils can have a profound impact on soils. This affects the balance of carbon and nitrogen gas emissions from soils and thus global climate change (Brevik, 2013). Carbon and Nitrogen cycles Changes in temperature and rainfall patterns can have a major impact on organic matter and processes that occur in our soils and in the plants and crops that grow from these soils (FAO, 2014). According to Brevik (2013), the Earth's climate system is changing due to changing levels of greenhouse gases in the atmosphere; the most important of these gases are carbon and nitrogen based. Since soils are part of the carbon and nitrogen cycles and carbon and nitrogen are important components of soil organic matter, the organic matter content

Changes in average temperatures and rainfall patterns, where soils will be affected by climate change, will also affect soil organic matter, which in turn will affect important soil properties such as aggregate formation and stability, water holding capacity cation exchange capacity and soil nutrient content. Exactly how soil organic matter will be affected by climate change involves extremely complex and interconnected systems that make it difficult to isolate a single variable, such as temperature or precipitation patterns, and draw meaningful conclusions about how this change occurs when only one variable affects the system under study. However, we do know that there is a possibility that soils may be releasing ever-increasing amounts of greenhouse gases into the atmosphere and losing their ability to act as an absorber for C as global temperatures rise. Organic carbon cycle models and studies of climatic cross-sections suggest a decrease in soil organic carbon. As a result, we have the chance to see negative impacts on the physical and chemical properties of our soils, which are essential for the production of food and fiber products. Carbon and nitrogen are the major components of soil organic matter (Brady, 2008). Organic matter is important for many soil properties, such as structure formation and maintenance, water holding capacity, cation exchange capacity, and for providing nutrients to the soil ecosystem (Brevik, 2009; 2013).Sufficient amounts of organic matter tend to be more productive than soils poor in organic matter (Brevik, 2009), so one of the biggest questions about climate change and its impacts on soil processes and properties involves how potential changes in carbon and nitrogen cycles will affect soils . Currently, our understanding of how changes in climate will affect carbon and nitrogen cycles is incomplete, meaning that additional research on these questions is needed (Daba et al., 2018). Water is present in all components of the climate system: atmosphere, hydrosphere, cryosphere, land surface and biosphere. The dynamics of the water cycle is one of the key variables determining the distribution and productivity of ecosystems. Changes in global climate will have significant impacts on local, regional and global hydrological regimes, which can affect ecological, economic and social systems. Water resources are one of the main components of natural systems that may be affected by climate change. The impact of climate change on precipitation, stream flows and groundwater recharge components will directly affect the availability of water resources under climate stress. The impact of climate change on water availability will depend on changes in precipitation (including changes in the total amount, pattern and seasonal timing of rainfall). In areas where rainfall increases sufficiently, net water resources may not be affected or may even increase. If precipitation stays the same or decreases, net water resources will decrease. Climate change will affect water resources through its impact on the amount, variability, timing, pattern and intensity of rainfall. Soils are intricately linked to the atmospheric/climate system through carbon, nitrogen and hydrological cycles. Changing climate will therefore have an impact on soil processes and properties. Manage water resources in a changing climate by applying Integrated Water Resources Management approaches in high vulnerability basins. Promote soil and water conservation practices. Implement water conservation and efficiency programs to reduce the amount of water required for irrigation, municipal and industrial users and improve basin-wide water supply. Regions most vulnerable to climate change should adapt strategies to manage climate change risk. Improve irrigation infrastructure in all vulnerable countries to cope with climate change risk. Groundwater development, such as rainwater harvesting, watershed management and rainwater harvesting, should be implemented on a large scale in all vulnerable regions. Improving rain-fed agriculture through watershed development and rainwater harvesting. Developing a basin-based integrated water resources management approach and constructing water storage structures to store excess water that flows during the wet season for use during the dry season. Raising public awareness about future climate change in the basin area and developing groundwater and effective rainwater harvesting technologies (Aydın & Sarptaş, 2017). It is known that climate change has some effects on plants. One of these effects is the occurrence of plant migration/change in the geography of plant species (Öztürk, 2002; Erlat, 2014; Haşlak, 2007]. The fact that species respond differently and at different levels to climate change and disrupted climatic regimes (precipitation, evaporation and temperature regimes, etc.) will cause disruption of the structure, productivity and geographical distribution of ecosystems [Öztürk, 2002]. Changes in precipitation and temperature regimes will cause plants that have adapted to the climatic characteristics of their geographies until now to face new climatic developments and to be under pressure. This situation will cause some plants to adapt, while others will succumb to competition due to climatic changes (Denhez, 2007). Türkeş et al. As stated in a study by 2000, since climate zones may shift hundreds of kilometers from the equator to the poles, as has been the case in the geological past of the globe, this will result in damage to native plants that are best adapted to climate zones; flora and fauna that cannot adapt to new climate zones will disappear (Denhez, 2007; Türkeş et al., 2000). The effects of climate on crops will also affect agricultural activities in the future. Climate influences crop quality variation under water and temperature stress and thus production potential [Kassam et al., 1993; Holzkaemper et al., 2011]. Therefore, climate is one of the main determinants of regional agricultural production suitability (Holzkaemper et al., 2011). The fact that climatic conditions vary according to time and space brings up the climatic suitability for the growth of plants and the geography in which they grow. Analyzing climatic suitability is essential for planners and landowners/managers to understand climatic suitability across time and space and to use this awareness to manage strategic resources, plan development and identify adaptation strategies (Holzkaemper et al., 2011; Salinger et al., 2000). As Holzkaemper et al., 2011, mentioned in their study, there are estimates that over several decades, the geographical suitability of warm-season crop plants, such as grain maize and grapevine, has shifted northward and to central Europe (Holzkaemper et al., 2011; Kenny et al., 1993). Maslin (2011) also reported that the total area suitable for growing Robusta coffee has decreased dramatically as a result of climate change and will be reduced by less than 10% as a result of a 2°C temperature increase. The study also predicts that only the highlands will remain, and that other areas will become too warm to grow coffee. This shows the vulnerability of many developing countries, whose economies rely on one or two agricultural products, to the effects of global warming (Maslin, 2011; Grid, 2014). Another striking example is the study by Jassogne et al. (2018). In the study, the coffee suitability of East Africa was analyzed both today and in 2030, and it was revealed that countries such as Burundi, Uganda and Rwanda, which are suitable areas today, will need to make more efforts for coffee cultivation in 2030 (Jassogne et al., 2018; Aydın & Sarptaş, 2018).

Changes in climate cause changes in temperatures, precipitation, humidity, number of snow-covered days, sunshine duration, clouds, evaporation, hurricanes, winds, air pressure, fog and sea levels. These changes in weather events due to climate change significantly affect socio-economic, cultural and environmental factors in society. One of the sectors that will be most affected by climate change is the agricultural sector, as it is directly affected by weather events. Changes in temperature levels, precipitation, humidity, number of snow-covered days, sunshine duration and evaporation rates cause climate change, leading to a decrease in agricultural production and yields (Akcan et al., 2022).

Due to the negative effects of climate change on the water cycle, many effects such as irregularities in precipitation regimes, floods, droughts and soil moisture changes occur. In Turkey, which is located in the Mediterranean Basin, which is predicted to be most affected by climate change on a global scale, the number of extremely hot days and therefore the severity of drought is expected to increase. Considering factors such as rapid population growth, urbanization and industrialization, the country is expected to be a water-stressed country in the coming years. According to the WWF Turkey (2014) Water Footprint Report, the water footprint of production across the country is approximately 139.6 billion m3/year, 89% of which is water use from agricultural production. In order to meet the demand in the agricultural sector as a result of changing climate characteristics and to protect this sector from negative impacts, many plans and practices are being carried out in Turkey on adaptation to climate change and mitigation of its impacts. In this context, the main objective of this study is to evaluate the possible impacts of climate change on water resources and agricultural sector in Turkey and to examine the impact of policies developed in this regard on agricultural practices. For this purpose, secondary data were used in the study. Literature on the subject was evaluated and interpreted. As a result, it is seen that there are not enough studies in terms of sustainability of agricultural production in Turkey in combating the effects of climate change. It is also predicted that food security will be negatively affected due to the problems in water resources in our country in the coming years. Agricultural activities can be sustained depending on natural resources. Factors such as temperature, precipitation, changes in the amount of carbon dioxide in the atmosphere, extreme weather events are effective in agricultural activities (Dellal & Butt, 2005; Dellal & McCArl, 2007). In addition, soil conditions are of great importance for the healthy development of a plant or an agricultural product. Temperature and precipitation conditions affect agricultural productivity and product quality by changing the moisture content in the soil and soil fertility. In this case, many effects of global climate change on natural resources directly affect agricultural production. The impacts of climate change on agriculture include hotter and less rainy periods, increased frequency of extreme meteorological events, decrease in water resources, increase in the severity and frequency of drought, increase in pests and diseases, deterioration of the ecosystem, loss of biodiversity, fertilization and spraying problems, deterioration of water and soil quality, shift in ecological areas, and rising sea level causing loss of coastal agricultural lands and fertile soils (Ministry of Agriculture & Forestry, 2022). Depending on these effects, many problems such as changes in plant growth periods, deterioration in product quality, increases in production costs and productivity in animal production can be experienced. In this context, this study aims to evaluate the possible impacts of climate change on water resources and agricultural production in the country. The policies implemented in this regard were examined and the impact of these practices on agriculture was analyzed. As a result of the secondary data analyzed and the evaluations made, it is seen that it is important to increase the steps necessary for adaptation to climate change in the agricultural sector, such as the implementation of irrigation methods that will prevent/reduce water losses or rain harvesting, not only in theory but also in practice on agricultural lands. All natural disasters that are directly or indirectly related to meteorological conditions are called meteorological disasters or natural disasters with meteorological character (Ceylan & Kömüşçü, 2007; Kadıoğlu, 2007; Kadıoğlu, 2007; Kadıoğlu, 2008; Kadıoğlu, 2012). Disasters such as precipitation, severe local storms, tropical storms, severe winter conditions, hoarfrost, frost, forest fires, desertification, lake and sea water rise, avalanches and floods, invasions of agricultural pests are among the disasters caused by weather conditions. Hail is the most common disaster in Turkey in recent years due to global climate change. Although the hail continues for a short period of time such as 5-10 minutes, the damage it causes in agricultural areas is quite high. The size of the hail grain and the fact that the plants are young and fresh are factors that increase the damage. For example, hail during the tillering, emergence or spike periods of cereals and during the flowering and fruit formation periods of fruit trees will definitely cause damage. During these periods, hail breaks the leaves and stems of cereals, lays them on the ground and damages the young branches of fruit trees (Nadaroğlu & Şimşek, 2022). For example, it is known that the heavy hail that occurred in Amasya between May 24-25, 2022 damaged the cultivated crops in agricultural lands in 53 villages. Especially in this region, crops such as cherries, peaches, wheat, corn, sugar beet, etc. suffered heavy hail damage (Amasya Governorship, 2022). On the other hand, the downpour and hailstorm that was effective in Çamardı district of Niğde on September 21, 2022 caused flooding in some regions and damage to apple orchards in some regions (Taşkın et al., 2022).

Waterlogging is a problem that adversely affects plant growth and yield, especially in irrigated agricultural areas and regions with high rainfall. At this stage, biological and chemical events in plants and soil are also altered. Oxygen deficiency, which affects nutrient and water uptake, has been shown to be the main cause of the damages caused by waterlogging. Plants need oxygen for cell division, growth, nutrient uptake and transport. Lack of oxygen causes the metabolism to switch from oxygenated to deoxygenated conditions. Generally, in soils saturated with water, the oxygen level reaches a level that is harmful to the plant within 48-96 hours. Tissues developing in reduced oxygen levels produce highly toxic products to survive. Germinating seeds and emerging seedlings are highly susceptible to waterlogging due to their high metabolic levels. Many cool climate cereals, legumes and especially maize tend to be more susceptible to waterlogging before the 5-6 leaf stage, when their growth point is close to the soil surface. Many cereals and maize, except winter wheat, can die if they remain in waterlogged soils for more than 48 hours when soil temperature exceeds a certain temperature.

Plants have adapted to waterlogging conditions through the formation of arenchyma, increase in the amount of soluble sugars, more glycolytic cycles, increase in fermentation enzymes and antioxidant defense mechanisms (Yavaş et al., 2011).

Changes in Soil and Root Environment When the soil is completely saturated with water, air pockets are filled and some physical chemical properties of the soil change. Soil redox potential (Eh) can be shown as a determinant of chemical changes during water accumulation in the soil. Soil redox potential generally decreases with water accumulation. This is not only an indicator of the oxygen level. Because competition for oxygen increases and affects the availability and amount of different nutrients. But changes in soil redox potential also affect the availability of organic matter such as Fe and Mn. Flooding conditions during both tillering and heading period significantly increase the Fe and Mn content of the soil (Yavaş et al., 2012). The reduction in soil promotes the release of cations and phosphorus. It also increases the production of ethanol, lactic acid, acetaldehyde, acetic acid and formic acid. Another soil chemical property is soil pH, which is significantly affected by water accumulation in the soil. Soil pH is negatively related to soil redox potential. Soil pH generally tends to increase in response to water accumulation. The increase in pH can be explained by the dissolution of carbonate and bicarbonate during early water accumulation. Soil pH also affects organic matter, mineralization, nitrification and hydrolysis of urea. The effect of limited oxygen on cellular metabolism gradually reduces the amount of oxygen in the root zone and has varying effects on plant metabolism. Oxygen-deprived conditions occur in soils subjected to waterlogging, with an increase in fermentation products around the root, CO, methane and volatile fatty acids 2. Surface water ponding and waterlogging significantly reduce crop yields in areas receiving more than 400 mm of rainfall each year. Waterlogging significantly damages the plant in the early stages (germination, emergence and seedling stage), when temperatures increase and plant development starts rapidly (stalk emergence in cereals). Waterlogging slows plant growth, reduces tillering in cereals and nodule formation in legumes. Waterlogging causes plant roots to die, which is associated with less water and nutrient uptake. Washout and denitrification reduce the nitrogen content of the plant and cause nitrogen deficiency. This leads to yellowness of the older leaves during the winter and nitrogen deficiencies increase the stress in the plant. Under these conditions, root and leaf diseases also increase. In soils where waterlogging occurs, plant root development is limited and nutrients cannot be taken up in soils that dry out after waterlogging due to superficial root development. In the case of soils that contain soil soils, waterlogging can lead to rapid death of plants. In many cases, drainage seems to be the best way to eliminate waterlogging and surface water ponding (Parent et al., 2008). Most of the agricultural areas in the world are damaged by waterlogging stress. Therefore, plants show different resistance mechanisms against waterlogging stress. These include hypersensitivity reaction, production of active oxygen species, synthesis of phytoalexins, structural changes in the plant cell wall, accumulation of lignin, phenolic compounds and proteins, arenchyma and adventitious root formation. For this reason, it is possible to minimize water accumulation, weeds, nutrient deficiency and diseases by removing excess water by drainage in agricultural areas where water accumulation occurs. Early planting and selection of late varieties will also help protect plants from waterlogging damage. Applying a high N content before plants are exposed to waterlogging will reduce losses through leaching or denitrification (Yavaş et al., 2011). Drought is a natural climatic phenomenon that occurs when precipitation is less than the long-term average and can occur anywhere at any time. Today, drought, one of the biggest global problems we face in the world, affects every stage of our lives, including the physical and natural environment, urban life, development and economy, technology, agriculture and food, clean water and health. The impacts of drought, the degree, duration and timing of which are extremely difficult to predict, are also closely related to human activities.

Drought is a natural phenomenon with significant economic, social and environmental impacts. Drought is different from other natural disasters in that its onset and end are difficult to determine. It gradually builds in strength and can persist for years after the event has ended. The effects of drought are usually first seen in agriculture and gradually spread to other water-dependent sectors. The meaning of drought in the agricultural sector is different from other sectors. This is because for plants, the water available in the root zone during their growth period is more important than the total rainfall during the year. Therefore, the lack of water in the soil that plants need during the emergence and development period is called agricultural drought.

It is estimated that our country is among the risk group countries in terms of the possible effects of global warming and that especially the Mediterranean and Central Anatolia regions will be more affected by climate change in the future.

It is possible to mitigate the negative effects of agricultural drought by taking precautions in the periods before drought and by proper planning in the periods of drought. Therefore, the measures to be taken in the period before the drought and the steps to be taken during the drought should be planned separately. Although it is not in our hands to increase the water supply by ensuring the continuity of precipitation, it is in our hands to reduce the negative effects of drought (Kapluhan, 2013 The water source of field soils is generally rain. In our country, rains fall in late fall, winter and early spring. These waters are used as irrigation water in the future and thus the water requirements of plants are met during periods without rainfall.

Some of the rainwater runs off the soil surface, some of it evaporates from the plant and soil surface and some of it passes into the soil. The water that passes into the soil is retained by the soil, and the part that is not retained passes into the ground water.

The slower and longer the rainfall, the better the infiltration into the soil. These precipitations are the most beneficial for plants. Regular and slow rainfall throughout the growing period ensures high yield and quality of plants.

Short periods of abundant rainfall occur mostly on hot days. Since most of this rainfall is lost through surface runoff and evaporation, only a small part of it can infiltrate into the soil. Therefore, they are not very useful for plant growth. They also have negative effects as they increase water erosion in the soil

Heavy rainfall washes away the soil, especially when the slope of the land is high and the vegetation cover is low, and the land loses its fertility. As it acidifies the soil, the amount of humus is lost and mineral matter is reduced.

It has a negative effect on the development of plants. Increasing soil water leaves the soil airless. In this environment, roots stop growing because they cannot get enough oxygen. Their vital activities are disrupted, they become unable to take nutrients and water. After a while, infections appear and root decay begins. If seeds are planted in the soil, the seeds do not germinate and rot, or even if they germinate, the young shoot cannot grow due to lack of air and eventually the room rots.

It causes flower shedding during the flowering period. Excessive moisture and rainfall disrupt pollination. Flooding (Excess Water) Stress:

-As a result of overflowing rivers, streams and creeks or excessive rainfall, soils that cannot pass water to the lower layers are temporarily covered with water. Plant growth is adversely affected, the amount of photosynthesis decreases and serious crop loss is observed.

-In waterlogged soils, oxygen is depleted within one to two hours. Under these conditions, as a result of the activities of anaerobic microorganisms, the amounts of Fe, Mn, H_2S, sulfides, lactic acid, butyric acid, etc. increase rapidly to toxic levels.

Rain accelerates growth during the development phase. Because rainwater is the best irrigation water. It has a small amount of foreign matter in its composition. It contains oxygen and nitrogen of the air in molten form. It washes the plants and opens their pores. It accelerates respiration and CO_2 assimilation. Precipitation ensures that the large cloddy soil left in the autumn tillage is broken down in the winter months, that some undesirable pests die with the effect of cold and frost, and that the soil gains a new furda structure in the spring and enters our service as renewed.

Water Stress (Drought Stress)

Water stress also has a significant effect on enzyme activity and enzyme amount in plants. In addition, the amount of abscisic acid (ABA; a plant hormone) increases 40-fold in leaves, while this increase is less in other organs including roots. Abscisic acid prevents the transpiration of water by closing the stomata. By reducing the growth of the plant's apex organs, it allows water to be used in the root system, thus allowing the root to go deeper and access more water.

Drought tolerance strategies include:

- Rapid maturation before drought and reproduction after rainfall,
- Retarding water loss by having deep roots,
- Measures to protect against transpiration or to store water in fresh tissues,

- Don't allow water loss from tissues and continue to grow when water is scarce but try to survive when water loss is severe.

Snowfall softens the air. It covers the soil like a quilt, preventing it from freezing and protecting the living things in the soil. In cold regions, spinach seeds are sown in late fall for spring cultivation. If the seeds have not plowed, the snow cover on the soil prevents the spinach seeds in the soil from freezing and dying in the freezing cold of winter. If the seeds have ploughed and rosette leaves have formed, it prevents them from vernalizing and flowering early in spring. As snow melts slowly over a long period of time, melt water enters the soil and increases groundwater levels. However, the low temperature together with the hoarfrost causes them to get cold and freeze.

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Hail is the enemy of plants.

- Their harmful effects increase as their size and rate of fall increase.
- Leaves are shredded, branches are broken, fruit tubers are damaged and even shattered. In this respect, it is an undesirable form of precipitation.
- However, as an indirect effect, it increases the water of water sources when they melt.

The rate of utilization of plants from RAW precipitation varies depending on the plant genus, species and varieties, environmental conditions and the intensity and duration of precipitation. For example, plants growing in arid regions with low soil moisture absorb more dew than plants growing in humid regions. However, in commercial vegetable cultivation, as it increases the humidity in the air, it helps to improve the quality of vegetables whose leaves are mostly eaten.

- Intense dew periods in spring maximize the likelihood of disease
- Harvesting of seed crops should be done early in the morning before the dew rises to avoid grain spillage.

Conclusion and Recommendations

The pain of rain is mainly in the soil, but its effects reach much farther. Any place that receives more than 25 inches of rainfall a year loses soil fertility unless there is enough summer heat to evaporate most of the rainfall. This includes the amount, type and seasonal growth of vegetation. Places with very low rainfall (below 5 inches) are known as deserts, which is a different problem for growing crops, but that is another topic. Irrigation or watering adds to the problem in very wet and dry areas. It can lead to more leaching or salinity problems. Probably no factor causes soil fertility to deteriorate as much as rain, whether viewed in the short term or in the long term. The situation is different in Nebraska, where the annual rainfall and snowfall is about 25 inches. Being from neighboring Iowa, I can tell you about summer downpours and routine knee-deep winter snowstorms. However, the total amount of precipitation is significantly less than what we get in the Maritime Northwest. As a result, the fertility of the midwestern and prairie state soils is significantly greater than ours. The amount of net moisture that runs off more than a few inches below the surface is lower. By fertility we mainly referring to the nutrient minerals that can be washed (leached) out of the top layer of the soil. These can be leached out as fast as they can be produced by "erosion" processes in the soil. However, the point that needs to percolate is that fertility is of paramount importance in the production of food with good nutritional quality. Nutrient quality in food, including livestock, cannot rise higher than the nutrient content of the soil in terms of mineral elements and the organic matter (humus) content of the soil in which it is grown. Your health rises or falls according to the nutrient content or concentration of your food. This factor is the biggest cause of health or illness or disease or discomfort in our lives. Yet, it is generally the most overlooked factor, even though Hippocrates told us this 2400 years ago. By nutrient content I mean proteins, vitamins, minerals, enzymes and various complex carbohydrate molecules. These nutrients can be measured or quantified in bulk using a device known as a refractometer and a BRIX number can be obtained; essentially a measure of the soluble solids in the plant sap. The higher the BRIX number, the higher the nutrient density within the plant and the greater the likelihood of greater nutritional health benefits for whatever consumes that plant, and also the less likely that plant is to get sick or be disturbed by pests. We know that organic matter or humus is essential in organic farming, but minerals are the key ingredient to supply in terms of improving soil fertility. We don't usually use vitamins and enzymes to enrich the soil. We can supply protein in the form of various plant and animal feeds, but it is the minerals that are essential for the system to work (along with organic matter). They also supply the nutritional needs of the microbes that produce vitamins and enzymes, which can be useful in feeding plants. Minerals are ultimately extracted from the rock particles that are the main parent material of soil. Water and even erosion play an important role in extracting these minerals, but they also play a major role in leaching them downward and sending them on their way to the ocean (Kline, 2012).

Considering the importance of agricultural activities in Turkey, taking the necessary measures to prevent serious losses in terms of production, consumption and trade, implementing the existing policies and plans in the field by supporting farmers, continuing with a holistic approach in an integrated manner with other plans developed on climate change throughout the country, including farmers in awareness and awareness raising activities and supporting stakeholder participation are important issues. On the other hand, it should not be forgotten that the studies on water resources and agricultural production activities, which are discussed within the scope of this study, are interrelated. Issues such as the use of water resources, methods of use and the amount of water consumed are of great importance. In this regard, it is necessary to increase applications such as water footprint, which measures the volume of water use, especially for the management of water resources and ensuring conservation-utilization balance. Determining water use or water needs in production is very important for all kinds of plans and policies to be prepared for the future (Taşkın et al., 2022)

Precipitation is the liquid or solid form of water that reaches the ground from the clouds and is measured in cm in the meteorology of our country and expressed in kilograms per square meter.

The extent to which the precipitation falling on the ground benefits plants is defined as precipitation efficiency. In short, rainfall that reaches plant roots after being absorbed by the soil is effective rainfall. The factors that determine effective precipitation are the intensity of precipitation, seasonal distribution of precipitation, precipitation remaining after evaporation from the soil or plant surface, precipitation lost by runoff from the soil surface, soil properties and plant water needs. Heavy rainfall has a negative impact on life in settlements and can also damage agricultural areas. Although the benefit or harm of light or heavy (heavy) rainfall to plants depends on many factors, heavy rainfall brings harm to plants, not benefit. This is because precipitation falling on the soil surface rapidly and with high flow rate flows over the soil surface before it has the opportunity to infiltrate (enter) the soil, and it erodes and carries the surface soil by scraping it, and cannot reach the plant root. However, if it falls on the soil at low speed and low flow rate, it slowly infiltrates into the soil and reaches the plant root. Precipitation falling on the earth at the same intensity is again not beneficial to plants due to rapid evaporation after a dry and hot weather.

As it is known, the rainfall in our country generally falls in late fall, winter and early spring and is used as irrigation water to meet the water requirements of plants in periods without rainfall. The water that passes into the soil is retained in the exchange surfaces (clays and organic compounds, humus, etc.) present in the soil, and the water that cannot be retained is filtered through the lower layers in the soil to pass into the ground water.

Extreme temperatures and extreme precipitation are expected to increase in the coming years due to global warming. As a matter of fact, one of the negative impacts of climate change is the “change in the intensity and distribution of precipitation”. So much so that the precipitation that should fall in a few months falls on the earth in a few hours, causing significant damage and damage. On the other hand, drought events are inevitable due to increasing temperature and decreasing precipitation.

All these weather events related to precipitation regime (heat waves, increase or decrease in precipitation) significantly affect productivity in agriculture. Changes in the amount, time or intensity of precipitation significantly affect agricultural production. Agricultural areas are mostly affected by excessive rainfall, floods and inundations. In fact, until recently, agricultural areas have been severely affected in many parts of our country where agricultural production is dependent on rainfall. Heavy rainfall not only adversely affects the agricultural sector, but also causes erosion and loss of the soil, which is the production environment since agriculture depends on soil. The topsoil, which is the fertile layer of the soil and 1 cm of which is formed as a result of centuries of time, is lost within minutes or hours by erosion. The transportation of soil, which is the most important production environment of agriculture, to rivers, lakes, dams and seas by erosion also damages agriculture, which meets domestic food needs, provides input to the industrial sector, provides our exports and is our source of livelihood. As a matter of fact, atmospheric conditions (meteorological events) affect the yield and quality of agricultural activities and not only cause food deficit, but also gain disaster characteristics with increasing rainfall intensity. Events such as frost, storms, heavy downpours and floods, drought, etc. significantly reduce agricultural production. Hail, which is one of the natural disasters of meteorological character, causes great damages and economic losses as it occurs in the months when agricultural activities are the most intense in our country. The hailstorms that have occurred in Turkey in recent years have become the fearful dream of our farmers and producers. Depending on their intensity, hailstones damage fruits such as strawberries, mulberries, raspberries or leaves. Wounds and bruises on the fruits reduce the quality and cause the fruits to rot or fall off. If the land where hail falls is sloping and there are no cover crops, floods and inundations cause great damage.

When precipitation suddenly falls on the earth with high speed and flow rate, it increases surface runoff. When surface runoff increases rapidly, it can cause streams to overflow or pond in agricultural areas without reaching the stream beds. In agricultural areas with low slopes, drainage channels must be provided to drain excess water, otherwise the rate of agricultural damage increases. Soil transported by erosion carries with it the minerals (nutrients, fertilizers, humus, etc.) necessary for plants, soil fertility decreases, excess water replaces oxygen in the soil and the roots are deprived of oxygen, root growth is retarded, nutrients and water cannot be absorbed, infections appear after a while and the roots rot, thicken and turn brown. In addition, as airless conditions increase in the soil, toxic compounds (methane gases, ammonia gas, sulfur compounds, etc.) are formed. It emits an odor. If sowing or planting has been done recently, the seeds do not germinate and rot, or even if they germinate, the young shoot cannot grow due to lack of air, the seedling cannot emerge, causing flower shedding, excessive rainfall disrupts pollination. Plant growth is adversely affected, the amount of photosynthesis decreases and serious crop loss is observed. The increase in air humidity and temperature in areas with excessive rainfall not only causes the development of fungal diseases in potato cultivation, but also reduces the starch content in potatoes. In sugar beet, during periods of heavy rainfall, the accumulation of carbohydrates in the tuber increases, while the sugar content decreases, and diseases and rot develop in the plants. Harvesting becomes difficult. Cabbages are not damaged by rainfall, on the contrary, they grow better. Cabbage grows very well with an increase in air humidity. Rainfall in the form of hail damages the leaves of the cabbage plant. Other than that, rainfall has a positive effect on the development and growth of cabbage as well as its quality characteristics.

Precipitation falling on the soil in low doses and over a long period of time transports some minerals (nitrogen, sulfur, etc.) from the atmosphere to the soil and helps to provide water and oxygen to the root zone of the plant in a balanced way. In general, among the various methods, the use of combined relative , humidity wind speed and duration,and air temperature allows for better discrimination of precipitation phase, which provides an important scientific significance and guidance for research in the fields of meteorology and hydrological processes (Sun et al 2022)

In order to reduce the negative effects of precipitation on agricultural lands; It is necessary to use the land according to its capabilities, to give importance to alternate cultivation, not to burn stubble, to adopt cover crop agriculture, to give importance to strip cultivation, flat curve agriculture and terracing. To increase soil organic matter (at least 3-5%), to form the plant pattern with varieties resistant to heavy rainfall, to research plants genetically resistant to rainfall stress, to concentrate scientific research on varieties suitable for drought and heavy rainfall stress. In the fight against climate change, it is imperative to increase scientific studies for the sustainability of agricultural production. Some of these scientific studies should be selected from studies focusing on the measures to be taken to ensure that food security will not be adversely affected due to the shortage of water resources in our country in the coming years. Modern irrigation systems will continue to be popularized. - In order to conserve groundwater, night irrigation will be encouraged along with restricted irrigation. - In order to expand the cultivation of crops with low water demand, basin-based production model will be made widespread. - Drip irrigation and subsoil drip irrigation methods, which are among the “Pressurized Irrigation Methods” that provide maximum water saving in agricultural irrigation, will continue to be developed and supported (Anonymous, 2021).

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