Project funded by EUROPEAN UNION

AGREEN
Community for climate-smart agriculture

Black Sea
CROSS BORDER COOPERATION

AGREEN

CROSS-BORDER ALLIANCE FOR CLIMATE-SMART AND GREEN AGRICULTURE IN THE BLACK SEA BASIN

Subsidy Contract No. BSB 1135

CROP MODEL

WALNUT GROWING UNDER DIFFERENT IRRIGATION WATER CONDITIONS

Common borders. Common solutions.

Project funded by EUROPEAN UNION

AGREEN Community for climate-smart agriculture

Black Sea CROSS BORDER COOPERATION

AGREEN

CROSS-BORDER ALLIANCE FOR CLIMATE-SMART AND GREEN AGRICULTURE IN THE BLACK SEA BASIN

Subsidy Contract No. BSB 1135

CROP MODEL

WALNUT GROWING UNDER DIFFERENT IRRIGATION WATER CONDITIONS

Climate-smart crop models, adapted to the environmental, social and economic conditions in the BSB region

The project **Cross-Border Alliance for Climate-Smart and Green Agriculture in The Black Sea Basin (AGREEN),** Ref. No. BSB 1135 is funded by the Joint Operational Program for Cross-Border Cooperation under the European Neighbourhood Instrument "Black Sea Basin 2014-2020", under Priority 1.2 "Increasing cross-border opportunities for trade and modernization of agriculture and related sectors".

Contents

1. CURRENT SITUATION AND JUSTIFICATION

Water, which covers a large part of the earth, has an indispensable importance for living things. However, only a small part of the water resources is usable. Unfortunately, the amount and quality of existing limited clean water resources are decreasing day by day due to population growth, rapid urbanization and rising living standards, agricultural practices based on heavy fertilizer and pesticide use, industrial activities and climate change (Saraoğlu, 2014). In order to protect natural resources, the use of optimum soil and water resources has become mandatory. In the studies carried out, it is expected that the temperature will increase as a result of global warming, the precipitation will decrease, and therefore decrease in agricultural production. As a result of this situation, it is necessary to make optimal use of existing production facilities for a sustainable production.

Since Turkey is located in a semi-arid climate zone, it is important to develop and use water resources in terms of quality and quantity. The annual average precipitation in Turkey is approximately 574 mm, corresponding to an average of 450 billion m^3 of water per year. Within the framework of today's technical and economic conditions, the surface water potential that can be consumed for various purposes is an average of 94 billion m^3 per year. Together with the groundwater potential determined as 18 billion m^3, the consumable surface and underground water potential of our country is 112 billion m^3 per year, 57 billion m^3 of which is currently in use. Approximately 72% of the water used in our country is used for irrigation purposes. 72% of the water used is above ground and 28% is groundwater. This consumption is followed by industry and drinking use sectors (Anonymous, 2021a).

When the water potential of Turkey is examined, it can be characterized as a country experiencing water scarcity with a usable water amount of around 1,600 m3 per person per year. According to the population projections made by TURKSTAT, the population of our country will reach 100 million in 2030. Within the framework of these estimations, the annual amount of usable water per capita in Turkey will approach 1,000 m3 in 2030 (Saraoğlu, 2014). On the basis of basins, it is seen that water availability and population density are not at the same rate. In the light of this information, Turkey is rapidly progressing towards becoming a country that suffers from water shortage and water stress in the future.

For this reason, it is important to use water economically and in an optimum way, and the potential of water resources should be evaluated by constructing storage facilities and studies for multi-purpose use are carried out. In addition, it is aimed to bring renewal projects to the fore in order to prevent water losses in the irrigations that are in operation, to use water more effectively and efficiently, to eliminate drainage problems that affect the quality of the soil, and to popularize the use of modern closed irrigation systems instead of classical open system irrigation schemes. With the application of modern irrigation methods, it is planned to increase the irrigation efficiency from 51% to 55% by 2024.

World walnut production is spread over an area of 1.1 million hectares as of 2018. 3.6 million tons of walnuts are produced on this area. Our country, which has a highly variable climate and a rich fruit growing culture, has a very important place in walnuts, as in most fruit species.

According to the world walnut production data, China met 56.1% of the total world walnut production in 2019. After China, USA comes in walnut production and its production is approximately 592 thousand tons. Turkey, on the other hand, ranked fourth in walnut production with a share of 5.0%. 48.4% of walnut production areas are in China, 11.3% in USA and 9.5% in Turkey (Anonymous, 2021b). Although our country ranks 4th in terms of walnut production in the world, it is insufficient to meet the demand in the domestic market. Therefore, our country is still in the importer position. With the support of saplings provided by the Ministry of Agriculture and Forestry, walnut production is expected to increase by 60 thousand tons in an 8-year period (Anonymous, 2020).

In the 2012-2016 Walnut Action Plan published by the Ministry of Agriculture and Forestry, one of the main objectives is to establish common ponds and pressurized irrigation systems to solve irrigation problems in afforestation projects. Within the scope of this target, the activities of determining the areas with water resource problems in the afforestation areas, creating the investment program, and implementing the projects are defined. In addition, it is planned to conduct field studies in order to switch to pressurized irrigation projects (Anonymous, 2012).

Despite the rapid increase in walnut areas, the increase in yield values did not occur at the same rates. On the other hand, although Turkey has important walnut areas, the yield values we obtained are at a low level. The fact that our yield values are low causes it not to meet our domestic consumption amount and therefore increases the walnut import amount. It is necessary to reveal the reasons why our country is able to close the supply-demand gap and the production does not increase despite the increase in walnut areas.

Turkey has an important potential due to walnut cultivation in almost every region. However, it is necessary to take measures to realize this potential. Support mechanisms of these measures can be achieved by delivering the results obtained from scientific researches to the producers. In this context, it is necessary to select walnut varieties suitable for the ecology of the region, to carry out technical and cultural agricultural practices such as pruning, fertilization, irrigation, mechanization in a way to protect natural resources, to carry out post-harvest processes and to inform producers.

The most important reason for the low yield values of walnut trees we have achieved in Turkey until recent years is that the trees are grown only in natural precipitation without irrigation. In fact, it is emphasized that it is very important to make irrigation applications in accordance with the technique in terms of the development, yield and product quality of walnut trees. Walnut is one of the fruits with a high demand for water due to its large tree structure and organs. On the other hand, natural precipitation is not at a level that corresponds to the plant water requirement in the regions where walnut cultivation is in our country, and irrigation practices are obligatory. Although seasonal water consumption varies according to climatic and regional conditions, age and type of tree, it is between 750 and 1500 mm. In years when natural precipitation is low and drought is high, irrigation applications should be between early spring and late autumn, and between June and October in normal times. Especially in the period that includes the months of June, July and August, which are the time of shoot progression and fruit ripening, the plant's need for water is the highest. Insufficient watering of walnut trees can cause a decrease in walnut size, sunburn, increased pressure from mites, increased diseases, and especially deep scab wounds. In addition, the effect of water stress on yield and quality depends on the degree of stress, the development period in which it is applied, and the duration of the stress. In the studies, it was determined that drip and sprinkler irrigation methods are more suitable for soil moisture distribution in the plant root zone of walnut trees. When the relationships between the applied irrigation water and walnut yield are examined, 54.3% water savings and 7.1% efficiency increase with drip irrigation, 35.0% water savings and 8.4% increase in efficiency with furrow irrigation, compared to the flood irrigation method, sprinkler irrigation with irrigation, 54.3% water savings and 4.5% yield increase were achieved (Li et al. 2013). In a study conducted to compare the drip irrigation method and micro sprinkler irrigation systems in China, it was reported that the drip irrigation method gave higher yield than the under tree micro sprinkler irrigation method in terms of walnut yield (Hu et al. 2010). In another study, Chandler walnut trees in northern California were evaluated under different water stresses. In this study, they stated that the walnut tree gave maximum yield under low stress (Ustin et al. 1991). In a study conducted in the USA, it was stated that the yield values changed with the amount of irrigation water in the experiment in which three different irrigation water was applied (Fulton et al. 2003).

Increasing temperatures and extreme weather events (hail or storms) cause significant decreases in yield in olive, vine or fruit trees. In extreme meteorological events such as high temperatures, severe storms or drought, it is necessary to increase productivity and ensure sustainability. Irrigation activities appear as an extremely important input in our region, where temperature increases and high evaporation are expected (Konukcu et al. 2019).

Irrigation practices, which are shown as the most important input for obtaining the desired yield from walnut trees, also cause some problems. Especially in walnut orchards established in areas that have lost their forest quality, the scarcity of water resources, the very low static levels of the existing groundwater, as well as the high initial investment costs of the drip irrigation system to be used and energy costs are among these problems. For this reason, the drip irrigation system to be used in walnut gardens should be well planned and operated. In order to design the most suitable drip irrigation system for walnut orchards, "soil-plant-water-climate and hydraulic" characteristics and appropriate irrigation time planning should be examined together. Irrigation time planning, which answers the questions of how much water and when, is important for the conservation of water and soil resources and the determination of the income values to be obtained by production. In a study conducted in China, the water use efficiency of 10-year-old walnut trees under different irrigation programs was examined. In the study, they determined that the plant water consumption values of walnut trees were between 585.6 mm and 840.3 mm in the micro sprinkler irrigation method, while it was 993.3 mm in the flood irrigation method. In the study, when evaluated in terms of water use efficiency (WUE), it was stated that there was an increase of 3.5% to 28.6% in under-tree sprinkler irrigation compared to flood irrigation (Zhao et al. 2010).

2. OBJECTIVES AND TARGETS OF THE RESEARCH

Our aim in first model, which will be prepared to reduce the effects of climate change, is "Conservation of Water and Soil Resources and maximization of efficiency".

For this purpose, the following objectives are planned to be achieved.

Target 1. Determination of crop water requirement for walnut trees grown or planned in the region

Target 2. Determination of the most suitable irrigation scheduling for walnuts in the regional conditions

Target 3: Maximizing efficiency and ensuring a sustainable production with minimum irrigation water

Target 4: Introducing a suitable irrigation plan for local farmers with an A class evaporation pan

Target 5: To reveal the usability of the drip irrigation method, which uses irrigation water most effectively for the protection of water resources, for walnut trees in the region.

Target 6: To reveal the possibilities of using the double lateral arrangement for the walnut orchards grown in the region.

Target 7: To reveal the possibilities of using leaf water potential, transpiration rate and stomatal conductivity measurements for plant-based irrigation time planning.

3. MAERIAL AND METOD

3.1. Material

3.1.1. Cultivar

In this study, it is planned to carry out irrigation trials on walnut tree in order to protect water resources and maximize efficiency.

3.1.1.1. General characteristics of walnut tree

Walnuts are long-lived trees. Walnut trees, which can reach 25-30 m in height, have a large crown width. If walnuts are grown from seed, they show a stronger development. Grafted walnut trees show a broad and vertical development depending on the variety and ecological conditions.

Depending on the variety, there are varieties that mainly produce fruit on the side branches or the end branches. Varieties that bear fruit on the end branches show upright development. Root structures are tap rooted and can go 3-4 m deep (Anonymous, 2020).

3.1.1.2. Choosing a suitable place for walnuts

This selection determines whether the cultivation will be successful or unsuccessful, and the climatic requirements of the walnut must be taken into account in the selection of the place. Local effect of temperature change in spring, mean spring air flow and wind velocity flow should be taken into account in site selection. The most important criterion that determines the suitability of the place is the spring temperatures. In places where early spring frosts and late autumn frosts are common, setting up a garden should be avoided or measures should be taken to minimize the damage. Since cold air will accumulate in pits, pit areas should be avoided. Also, care should be taken as areas with dense trees create frost pockets. For this reason, gardens should not be established closer than 25 m to the forest area. There should be sufficient soil depth in the place where the walnut garden will be established. It should not be forgotten that the walnut has a strong and deep root structure. In areas with terraces and undulating topography, the soil may be more suitable for walnut cultivation. Setting up a garden on the slopes can also help protect from spring frosts (Sen, 2011).

3.1.1.3. The climate demand of the walnut

It is very sensitive to late spring frosts and early autumn frosts. Great care must be taken in setting up the garden. Another risk is that the summer months are very hot. Especially when the temperature rises above 38ºC, it causes problems in fruit quality.

In fact, walnut trees are highly adaptable to different climatic conditions. The cooling requirement of the walnut tree is around 800-1800 hours, and it can be grown even in areas 1700 m above sea level.

3.1.1.4. Soil request of walnut

Walnut can be cultivated on a very wide scale in terms of soil. In terms of ground water, deep soils that are not higher than 2.5-3.0 meters and maintain their humidity are more suitable for walnut cultivation (Anonymous, 2020).

3.1.1.5. Walnut varieties suitable for the region

There are many varieties in walnut cultivation in our country. However, the most popular of these varieties are Sütyemez1, Chandler, Pedro, Kaman 1, Maras 18 varieties.

In this study, it is planned to use the Chandler variety. Chandler is one of the varieties that stand out in terms of yield and quality. It is cultivated all over the world, especially in the USA. It has a rapidly increasing cultivation area in our country in recent years. The shell weight of this variety is 13.4 g, and its internal yield is 49%. This variety definitely requires Franquette and Cisco kinds of pollinators. The trees to be used in the experiment are seven years old. Walnut trees were planted in the area in 2014 as part of the TUBITAK project (no. 114O532) (Erdem, 2018).

3.1.1.6. Planting walnut saplings

It is important to use certified and grafted seedlings for planting. Grafted walnut saplings are available as open-rooted or tubular. By purchasing certified seedlings, it can be ensured that they are free from diseases and pests. Open rooted and tubed seedlings differ in terms of planting time and development time. However, the growth rate of open rooted seedlings is higher. On the other hand, tubular seedlings are much easier to transport than open rooted seedlings. Open rooted seedlings are recommended to be planted in autumn in regions with mild winters. Before planting, 3-4 shovels of barn manure or phosphorus fertilizer should be placed 50 cm under the soil. After the soil is filled on the fertilizer, the roots of the seedlings remain in the soil without curling the roots. At this point, care should be taken to keep the grafting site above the ground.

3.1.1.7. Tillage in walnuts cultivation

In the spring, a deep plowing is carried out when the mellowness of soil. With the tillage carried out in this period, soil aeration and removal of existing weeds are ensured. In the following periods, weed control can be done depending on the need. Plowing with the plow to be made in the fall will help to keep the rain and snow waters.

Especially in the first years of the tree, it is necessary to stay away from plow ploughing in order not to damage the roots. If plowing is required, the tree can be carefully plowed from the surface between the rows. If the tree is on the row, it is recommended to cultivate the soil with a disc harrow or rake in order not to damage the walnut roots with an exposed root structure.

3.1.1.8. Fertilizer needs of walnuts

In order to increase the yield and quality in walnut production, it is necessary to give the nutrients needed by the plant. A lack of plant nutrients can cause a pause in growth and development. The high amount of lime in the soil prevents the uptake of some elements. Iron deficiency is common in calcareous soils.

In the fertilization process, first of all, the soil to be taken from the land and the leaf samples to be taken from the orchard should be analyzed, and then fertilization should be done according to the need. The plant nutrient that the walnut is most sensitive to is nitrogen. On the other hand, phosphorus deficiency in the soil must be eliminated. Phosphorus is extremely important for walnut kernel quality.

3.1.1.9. Pruning and care for walnuts

The purpose of pruning in walnut trees is to develop a strong trunk and to form strong main branches around it. With pruning, trees are prepared against excessive fruit, snow and ice damage or other negative effects (Şen, 2011). Pruning in walnut trees should generally be done during the winter rest period when the weather is not cold. In regions where the winter months are not cold, pruning can be done in autumn after the trees have shed their leaves. Pruning can continue until the trees wake up at the end of winter (Anonymous, 2020).

In order to create the desired crown system in the first planting, pruning is done over the active 5-12 buds. In the first year's winter pruning, the top branch is cut from 180 cm and pruned is done. In order to increase the yield in the following years, thinning should be done by pruning the branches that are not too thickened from the bottom, form the crown surface, and the branches should be pruned at 2- or 3-years branch levels.

3.1.1.10. Irrigation and irrigation water requirement of sunflower

Irrigation is the controlled delivery of the part of the water that plants need in order to maintain their normal development, which cannot be met by precipitation, to the root zone of the plant. On the other hand, the irrigation method is the application of the irrigation water needed by the plant to the plant root zone. The availability of sufficient moisture in the root zone of the plant during the growing season is important for plant growth. However, irrigation water applied more or less than necessary causes yield loss rather than yield increase. In fact, for each plant, the yield increases by a certain amount with irrigation. The irrigation water to be applied less than necessary will cause the maximum yield value expected for the walnut tree to not be achieved.

Due to poor drainage conditions in the plant root zone, the air-water ratio needed in the plant root zone turns in favor of the water, causing the oxygen amount to fall below the desired level. In this case, it causes a slowdown in the proliferation of stem cells by dividing, and the inability to achieve the desired level of root development, and the activities of soil microorganisms slow down. In addition to decomposition of organic matter and reduction of plant nutrient intake, it causes the formation of harmful compounds that oppose the uptake of soil nutrients.

Irrigation activity is actually a production activity with many benefits. We can list them as follows.

- Damages of short-term droughts are prevented by irrigation.
- Increases the yield value taken from the unit area.
- Increases plant quality.
- Sustainable production is ensured.
- Irrigation provides protection of plants from frost.
- It helps to soil reach mellowness after the harvest.
- In pressurized irrigation methods, pesticides and fertilizers can be used during irrigation application.

• It improves the environmental conditions by softening the air in the planted area.

• Wind erosion is prevented in the soil moistened with irrigation.

• Hardpan is softened in the soil.

Irrigation time planning has two elements. These are the time to start irrigation and the amount of irrigation water to be applied in each irrigation. Irrigation time and the amount of irrigation water to be applied in each irrigation vary according to the characteristics of the plant to be irrigated, the depth of the soil to be wetted with irrigation, namely the plant root depth, the available water holding capacity of the soil, the moisture level to start irrigation and the crop water requirement. In order to calculate the irrigation water, the effective root depth for the walnut tree (it varies depending on whether the plant is a sapling or an adult) must be known. The root depth, which is smaller when it is a sapling, increases in direct proportion to the growth of the upper parts of the plant. In addition, the amount of irrigation water during the summer months is higher than per season and harvest date.

Although seasonal water consumption varies according to climatic and regional conditions, age and variety of tree, it is between 750-1500-mm. Irrigation applications should generally be done between June and October. On the other hand, irrigation activities should be carried out between early spring and late autumn in relatively dry periods when precipitation is below seasonal normal. The period when the walnut tree's irrigation water requirement is the highest is especially in June, July and August, which are the time of shoot progression and fruit ripening. In addition, the effect of water stress on yield and quality depends on the degree of stress, the development period to which it is applied, and the duration of the stress. It has been determined that drip and sprinkler irrigation methods are more suitable for soil moisture distribution in the plant root zone of walnut trees.

3.2. Method

3.2.1. Study area

The research area of Tekirdag Viticulture and Research Institute was chosen as the study area in the research. The main reasons for choosing this land are that the research area is close to the university, there is an orchard that can be experimented already, and there is a suitable water source for irrigation activities.

3.2.2. Water source

There are 7 wells in total as a water source on the land belonging to the Viticulture Research Institute. The water drawn from the streams and wells passing through the research area is collected in 4 storage pools at different points and the rested water is used for irrigation purposes during the season. The flow rates of the wells used as water sources vary between 12-20 L/s. The wells in the institute generally have a static suction height of 2-6 m, allowing the use of water with relatively low energy.

3.2.3. Soil and topography

Since sunflower is a deep-rooted plant, it is a more tolerant plant than water sensitive plants. Soils with high water holding capacity are ideal for sunflowers. In saline soils, the tolerance of sunflower is higher than that of plants such as maize, broad beans and beans. Here, according to the variety characteristics, it can be helped to preserve the yield by choosing the varieties with higher salt resistance in saline soils.

The soils of the study area have a clay-loam texture, are not problematic in terms of salinity, contain low lime and organic matter. The slope in the western parts of the land decreases from 15% to 1.5% towards the east. (Orta, 1997).

3.2.4. Irrigation water quality

Many parameters affect the quality of irrigation water. However, in practice, water quality is evaluated from two different perspectives. The first of these is extraneous matter in the water source. Soil pieces such as sand, clay or plant residues in the water source should be determined very well, especially in the studies where the drip irrigation method is applied, as they cause clogging of the drippers. If the stream bed is used as irrigation water, parts such as sand-clay and moss and plant parts will probably enter the irrigation water with the pump. In this case, appropriate infiltration equipment should be placed in the control unit at the beginning of the drip irrigation system. It is recommended to keep the suspended materials in the irrigation water in the resting pool in order to prevent them from being included in the system. Thus, the solids in the water will settle and they will be prevented from entering the irrigation system. Due to the use of well water in the research area, the irrigation water is first taken into a resting pool, and water is taken from this rested pool to the system during the season. Another parameter is its chemical content. Of course, the amount of macro and microelements is important. However, especially salinity and Sodium Adsorption Ratio (SAR) values come into prominence when considering the effect on the plant and preventing the system from working.

As much as possible, the irrigation water sample is taken from the moving areas of the water, instead of the stagnant areas, with glass or black-painted plastic containers, approximately 1 l samples are taken and these should be tested in a nearby laboratory as soon as possible. Although there are many classification systems prepared for irrigation water quality classification, the most widely used one is the classification developed by the US salinity laboratory. Accordingly, irrigation water salinity and Sodium Adsorption Ratio (SAR) values are prepared for this purpose and marked on the chart, and classification is carried out. There are four classes for both salinity and SAR. Quality decreases from Grade 1 to Grade 4. While first class irrigation water can be applied to all plants, as the number of classes increases, it is offered for use in plants with higher tolerance to salt and SAR. The water samples taken from the research area were tested at Kırklareli Atatürk Research Institute. As a result of the test, the water resources were determined as T2S1 according to the classification developed by the USA Salinity Laboratory. Accordingly, our water source was determined as 2nd class in terms of salinity and 1st class in terms of sodium.

3.2.5. Irrigation system

Irrigation water to be taken from the water wells in Tekirdağ Viticulture Research Institute will be pumped into the storage pool at the beginning of the trial area with closed pipelines.

Irrigation water taken from the storage pool by pump, after passing through the control unit consisting of hydrocyclone, sand-gravel filter tank and disc sieve filters, reaches 6 atm. It will be conveyed to the research area with the help of operating pressure, 50 mm outer diameter hard PE pipes. In addition, manometers will be placed in order to control the pressure in the system. Manifold pipelines for each trial plot will be formed from hard PE pipes with 40 mm outer diameter. It is planned to lay a double row lateral line on each row of trees within the trial plots.

3.2.5.1. Pump and Control unit

In the drip irrigation system, the irrigation water must be given to the system after it has been filtered very well. Failure to perform the filtration process properly causes the drippers, which are the crucial elements of the system, to become clogged and the uniform water distribution in the field parcel. On the other hand, in order to control the pressure required to be created in the system or to give the plant nutrients together with the irrigation water, the relevant equipment must be placed in the control unit and operated as required. In order for the system to work as desired, a control unit consisting of hydrocyclone, sand gravel filter tank, fertilizer tank, disc filter, pressure regulator and manometers and valves will be installed in the control unit (Yıldırım, 1996).

3.2.5.1.1. Hydrocyclone

It is a tool used to prevent sand particles that may be in the irrigation water from entering the system. Water enters the wall at the top of the hydrocyclone and descends along the wall. Then the water rises upwards from the hydrocyclone center. During the rise of water, heavy sand particles accumulate on the bottom and are prevented from entering the system.

3.2.5.1.2. Sand-Gravel Filter Tank

After the sand and gravel that may enter the system are captured by the hydrocyclone, a sand-gravel filter is used to keep the smaller particles (sediment and floating matters) remaining. In the sand-gravel filter, the water enters the tank from the top, while the water passes through the gravel and sand layers, it filters the irrigation water and keeps the sediment and floating materials. The pipes in the system, which are wrapped with a sieve filter, prevent the exit of the sand from the tank. From time to time, the residues accumulated in the sand and gravel filter, which is operated in reverse with the pipe inlets under the tank, are washed and cleaned.

3.2.5.1.3. Fertilizer tank

One of the most important advantages of the drip irrigation system over the surface irrigation methods is that plant nutrients can be applied to the system together with the irrigation water. Although there is a chance to use solid and liquid fertilizers as plant nutrients, the fertilizer must be given in a fully soluble form in the drip irrigation system. The pressure difference between the inlet and outlet points of the fertilizer tank is created with the help of valves placed on the main pipe in the control unit. Thanks to this pressure difference, fertilizer entry into the system is carried out. In irrigations without fertilizer application, the fertilizer tank is bypassed. In irrigations where fertilizer application will be made, liquid fertilizer and irrigation water are mixed in the fertilizer tank according to the size of the land to be irrigated and the fertilizer requirement. The mixed manure is left to the system and the fertilization process is carried out.

3.2.5.1.4. Disk filter

Disc filters directly affect the life of the drip irrigation system. The water flow paths on the drippers are manufactured very narrow to reduce the pressure. The water flows so slowly that even very small residues that come to these points can cause the dripper to become clogged. Clogging of drippers is actually the biggest maintenance problem in drip irrigation system. Cleaning or replacing drippers is an expensive operation. On the other hand, drippers that are not carried out on time cause a uniform distribution of water in the field. Failure to achieve uniform water distribution causes yield reductions. It is recommended to use a sieve or disc filter after the fertilizer tank, depending on the need. The disc filter is placed in order to prevent the sediment and floating substances that cannot be filtered through the sand-gravel filter and the fertilizer particles entering the system during fertilization from reaching the drippers. Since disc filters have smaller spaces compared to hydrocyclone and sand-gravel filters, it is recommended to be washed and cleaned after each irrigation as much as possible.

3.2.5.1.5. Manometer

Pressure gauges are one of the indispensable elements of the drip irrigation system. Manometers provide vital information about the irrigation system, helping to reveal leaks, blockages and filtration problems within the system. The pressure differences obtained from the inlet and outlet points help to reveal possible problems within the system. However, the point to be noted here is that the manometers placed in the system must be of the same type. Otherwise, it should be noted that the measurements may mislead users. In addition, manometers are also used to reveal whether the system pressure is provided or not.

3.2.5.1.6. Pressure regulator

Pressure regulators will be used to keep the pressure under control in the irrigation system and to maintain a constant pressure. With the pressure regulator, the pressure of the water in high-pressure systems is reduced to the desired value, preventing the equipment in the system from being damaged due to high pressure. Pressure regulators can be placed after the disc filter as well as at the manifold pipeline inlet.

3.2.6. Irrigation method

The drip irrigation method was chosen to irrigate the walnut trees. The basis of the drip irrigation method is to apply a small amount of irrigation water to the soil in the root zone of the plant at frequent intervals, without creating a lack of moisture in the soil and stress on the grown plant. In the drip irrigation method, after the irrigation water is taken from the source, it is approximately 1-1.5 atm with a closed pipe system. The aid of drippers is applied to the root zone of the plant under low pressure, such as in this method, water is applied to the root area in the form of drops by drippers. In this method, the existing irrigation water is applied in the most effective way due to wetting the bottom of the crown area of walnut trees.

The drip irrigation method has many advantages over other irrigation methods. For example, with the drip irrigation method, the development of plant diseases and pests is prevented. Irrigation water requirement is less than other methods, so that water resources can be protected and a sustainable agriculture can be achieved. With the drip irrigation method, losses are reduced by evaporation due to the less wetted area compared to other methods. Since frequent irrigation ensures sufficient moisture retention in the root zone of the plant, the plant stress level will be kept at a minimum and yield will be maximized. With the drip irrigation method, energy and labor costs are saved because the plant nutrients are given with the irrigation water.

In the drip irrigation method, drippers wet a circular area. In the vertical soil section, this wetting area creates a shape similar to an onion head. Drip irrigation is the most suitable irrigation method for saline soils, as salt is collected on the wet area walls and removed from the root zone during irrigation. Other operations can be carried out easily due to the fact that there is a dry area between the walnut trees. It is the most economical method where water resource is scarce.

3.2.7. Applications of Irrigation Water

During the research, the trial subjects were based on the determination of the irrigation water requirement. It will be tried to determine the irrigation practices that maximize the yield and experience the least loss in yield under water constraint. During the research, similar tillage, fertilization, spraying, etc. techniques will be used, in all matters in the walnut garden

During the research, 4 different irrigation issues were determined in order to compare the effects of the amount of irrigation water applied in different amounts depending on the amount and the walnut trees grown in rainfed conditions. The experiments are planned to be implemented as follows.

- **I_1:** The subject of the trial, in which 75% of the evaporation amount measured in total for 5 days from the A Class evaporation pan is applied. Irrigation water equal to 75% of the total evaporation amount measured for 5 days from A class evaporation pan will be applied to these trial plots.

- **I_2:** The subject of the trial, in which 100% of the evaporation amount measured in total for 5 days from the A Class evaporation pan is applied. Irrigation water equal to 100% of the total evaporation amount measured for 5 days from A class evaporation pan will be applied to these trial plots.

- **I_3:** The subject of the trial, in which 125% of the evaporation amount measured in total for 5 days from the A Class evaporation pan is applied. Irrigation water equal to 125% of the total evaporation amount measured for 5 days from A class evaporation pan will be applied to these trial plots.

- **I_4:** test subject without irrigation. It was added as a control group in order to reveal the change in the yield and quality of the trees grown in a similar environment in rainfed conditions with the irrigation studies that were the subject of this experiment.

The research will be carried out in randomized blocks according to the split plot design with 3 replications. Plots will be randomly determined by lot and each trial will be carried out in 3 repetitions to minimize errors. Each trial plan is 32x24 m in size. There are 12 walnut trees in total in each parcel. However, during the trial, measurements will be carried out on two walnut trees located in the middle of the plot in order to prevent the effects that may occur from the side plots.

In order to determine the effectiveness of irrigation applications during the irrigation season, it is necessary to determine the amount of moisture that can be used by the plant. It is necessary to determine the soil moisture constants in the trial area. Plants can use the moisture in the soil between two moisture contents called Field capacity and wilting point. However, the amount of moisture in the soil remains around the field capacity value, which means more comfortable water intake by the plants. When the amount of moisture decreases and reaches the wilting point, the plant has difficulty in getting the moisture it needs. Therefore, during plant development, the amount of moisture in the soil is tried to be kept around the field capacity with irrigation. The effectiveness of irrigation will be tried to be revealed by moisture measurements to be made in the root zone of the walnut tree before and after irrigation activities during the irrigation season.

3.2.8. Soil and Irrigation Water Properties in Research Area

3.2.8.1. Available Water holding capacity

Another parameter affecting irrigation water is the water holding capacity of the soil. The water that is between the field capacity and the wilting point and can be easily taken by the plants is called usable water. The amount of moisture remaining between field capacity and the wilting point is very important for plant growth and is referred to as available water holding capacity. This value is low in light-textured soils and high in heavy-textured soils. For this reason, irrigation water should be applied in low amounts at frequent intervals in light-textured soils, and less frequently but in larger quantities in heavy textured soils.

In general, if working on a parcel with sandy soil, the usable water holding capacity can be taken as 40 mm for 1 meter depth. While the average usable water holding capacity is 105 mm for a sandy loam soil with a medium water holding capacity, a value of 175 m can be accepted for clayey textured soils, which is a heavy textured soil. Available water holding capacity for each plant is calculated based on both the soil texture and the effective root depth. As the effective root depth increases, the amount of moisture that can be used by the plant also increases. Therefore, while a study is being carried out for plants with deep root structure, the water potential becomes larger due to the increase in the depth at which water can be supplied in the soil. The fact that the water intake is higher than the surface rooted plants allow the moisture amount to be started to be kept above 50%, thus allowing wider irrigation intervals to be created. In this case, there is a chance for water users to irrigate at wider intervals instead of dealing with irrigation activities at frequent intervals in the field.

Usable water holding capacity is actually the amount of soil retained moisture between field capacity and wilting point. Therefore, in order to determine the usable water holding capacity of the field parcel, it is necessary to determine the field capacity and wilting point for that parcel.

3.2.8.2. Field Capacity

It is defined as the amount of water held by soil particles against gravity under free drainage conditions. At this point, gravitational forces and capillary forces are in balance. The field capacity value varies according to the texture of the soil, its structure, the shape of the soil particles and the condition of the pores. The air humidity balance around the field capacity is at a sufficient level for many cultivated plants. Therefore, it is not desirable to increase the soil moisture above the field capacity in irrigation applications.

As the field capacity can be determined in laboratory conditions, it can be determined very easily in field conditions. For this purpose, after an area of 1 m2 is surrounded by banks, the soil is fully saturated with water. Depending on the soil texture, the amount of water held in the soil against gravity after 48 hours gives the field capacity for that soil.

The field capacity is high in heavy textured soils such as clay, clayey-loam, and low values are seen in light textured soils such as sandy. The amount of moisture kept under an average pressure of 1/10-2/3 atm, depending on the soil texture, represents the field capacity for that soil sample. If an average value is to be taken, the amount of moisture kept under 1/3 atm pressure can be taken into account for the field capacity (Richard and Weaver 1944).

3.2.8.3. Wilting point

The wilting point is the amount of moisture in the soil at the moment when the plants begin to wilt continuously and cannot get water from the soil through their roots. Even if the soil is watered after the plant reaches this point, it will not be possible for the plant to return to its former state. Almost all of the cultivated plants grown in a particular soil wither continuously at the same soil moisture level. The humidity value, in which the plants start to absorb water from the soil and begin to wilt continuously after this point, represents the wilting point value. In order to determine the wilting point in field conditions, as a result of not irrigating a plant grown in good conditions, the amount of moisture in the soil will decrease and when it drops to a certain level, the wilting symptoms observed in the plant mean that the wilting point has been reached for that soil.

The wilting point represents the amount of water retained by the soil particles under an average of 7-40 pulses of pressure. While 7 atm pressure is taken into account in light textured soils, the amount of water held by soil grains under 40 atm pressure in heavy textured soils expresses the wilting point value. For a normal soil, the amount of moisture held by the soil under 15 atm pressure represents the wilting point (Tamsa, 2013).

3.2.8.4. Amount of moisture allowed to be consumed

Since each soil has different amounts of usable moisture and the tolerance of each plant to water is different, irrigation activity should be carried out after a certain amount of available water holding capacity is consumed. In general, 50% of usable water is allowed to be consumed. This value can be taken as 0.30 for drought sensitive plants and 0.75 for resistant plants. For walnut trees, it is recommended to start irrigation activities when 50% of the available water holding capacity is consumed.

3.2.9. Infiltration rate

The infiltration rate of the soil is the rate at which water enters the soil vertically from a certain surface for a certain period of time (Gardner 1967). The infiltration rate, which has the velocity dimension, is expressed in cm/h or mm/h. infiltration rate is used to determine the amount of water that will pass into the runoff after rains and to select and project irrigation methods. While the infiltration rate is used to determine the flow lengths and flow rate in surface irrigation methods, it plays a role in determining the head flow rate and arrangement intervals in the sprinkler irrigation method, and in determining the dripper flow rate and the dripper spacing in drip irrigation method.

Double cylinder infiltrometer instruments are used to determine the infiltration rate, which is extremely important for effective irrigation in different irrigation methods (Delibas 1994). These cylinders with a diameter of 25 to 40 cm and a height of 45 cm are driven into the soil in such a way as to intertwine. The amount of leakage measured in the cylinder within certain time intervals is measured. Measurements made at frequent intervals (10-minute intervals) are continued by increasing the interval. Measurements are usually performed at intervals of 3 times 10 minutes, 2 times 15 minutes, 2 times 30 minutes, 1 time 60 minutes and a sufficient amount of 120 minutes. When two consecutive measurement values measured in the same time interval are the same, the measurement is terminated. Depending on the soil type, the infiltration rate is usually fixed at intervals of 120 minutes in medium and heavy textured soils. It can be taken as 50 mm/h for sandy soils, 25 mm/h for sandy loam soils, 13 mm/h for loamy soils, 8 mm/h for clay loamy soils, 2.5 mm/h for silty clay soils and 0.5 mm/h for clayey soils.

3.2.10. Agricultural Technique

Weeds need to be cleaned because they cause the consumption of water and nutrients they need in the root zone of fruit trees. During operation, mechanical and manual cleaning will be done to prevent weed growth that may occur in the system. For this purpose, if there is a need for weed cleaning between rows during the season, mechanical weed control will be carried out due to the freedom to work. In mechanical cleaning, care should be taken not to damage the roots of the walnut tree while ensuring the cleaning of weeds. For this reason, you should be very careful in places close to the root zone and try not to damage the roots.

Since lateral lines are laid on the rows, mechanical cleaning is not possible in these areas. Therefore, it is planned to carry out weed cleaning manually in these areas. A scythe or similar tool can be used to control weeds in the areas under the crown.

By mowing before the flowering period, the growth of weeds can be prevented and the need for green grass for the animals can be met. In addition, in this method, the development and growth of weeds and their hosting of other diseases and insects are prevented (Anonymous, 2017).

One of the most important points in weed control is to prevent the entry of weed seeds or parts from outside. For this purpose, all agricultural tools and machines that have been used in the area contaminated with weeds must be cleaned before entering the garden.

Controlling diseases and pests in walnut orchards by monitoring the population density of pests and their natural enemies helps to achieve the most accurate result. In case the economic damage threshold is exceeded, weed control should be done for the disease and pest.

In walnut orchards, the main disease is walnut anthracnose and the main pest is codling moth. During the walnut harvest in August-November, workers should be provided with gloves to work. Since they constitute a source of infection for walnut anthracnose disease, the fruit stalks remaining on the tree definitely should be cleaned during pruning. If diseased walnuts are detected, they will be destroyed. 2% Bordeaux slurry application after harvest, 1.5% after pruning and 1% before buds have start to swell should be applied for protection from diseases.

3.2.11. Evapotranspiration and measurement methods

Evapotranspiration refers to the sum of the water loss by the plant through transpiration and the water loss from the soil where its roots are located. It is usually expressed in depth and in mm. Since it is difficult to measure evaporation and transpiration separately in practice, it is preferred to measure evaporation and transpiration together in irrigation applications. The important thing here is to evaluate the moisture reduction in the soil in terms of irrigation. Plant water consumption is determined daily, weekly and for different time periods. It is determined for short periods is determined in response to the question of irrigation time planning to be applied for the plant during the growing season, that is, how much water will be applied and when. The value for the month or week with the highest evapotranspiration is used to determine the capacity of the irrigation system to be operated. In other words, evapotranspiration calculated for the peak period reveals the amount of water required to be carried by the main canal in the irrigation area. The seasonal value of evapotranspiration, on the other hand, expresses the storage capacity that can meet the total amount of water needed for the irrigation area during the season. The amount of seasonal plant water consumption is, the storage structure to be established should be above this need.

Plant water consumption is affected by many factors. These are generally seen as climate, soil and plant factors. Among the climatic factors, we can list temperature, solar radiation, wind speed, relative humidity, sunshine duration, daylight hours. As the sunshine duration and daylight hours increase, the amount of evaporation from the soil surface increases. Increasing the temperature will increase the transpiration activity of the plant. The humidity around the plant has the opposite effect, and when the humidity is high, transpiration slows down. The wind contributes to the removal of moisture around the plant and to provide of a dry air environment. Therefore, wind is a factor that positively affects transpiration activity in plants.

Soil factors are soil moisture, soil tillage and vegetation. The amount of moisture in the soil causes an increase in evapotranspiration. While the temperature and the amount of evaporation from the soil exposed to the sun will increase thanks to sufficient humidity, there will be an increase in water loss through transpiration with the provision of sufficient moisture. It causes an increase in the amount of evaporation from the surface, especially in the soil at the saturation point, and an increase in evapotranspiration. The fact that the soil surface is processed means that the air flow in the soil is provided more easily. In this case, an increase in evaporation losses from the cracks formed in the soil is caused. No-till farming is recommended in order to prevent soil moisture loss.

Plant factors are the type of plant, the growth period and the length of the growing season. The number of pores in the leaves of the plant and the size of the leaves directly affect the amount of transpiration, thus causing an increase in plant water consumption. Therefore, evapotranspiration of broad-leaved plants is higher than that of coniferous plants. On the other hand, the water consumption values of plants vary greatly depending on the length of their development period and the period they are in. In general, a longer growth period results in higher evapotranspiration. When the plant development periods are examined, since the plant water consumption in the first period is mostly based on evaporation from the soil, water consumption can be reduced by not wetting the entire soil in these periods, especially by using the drip irrigation method. In general, flowering and fruit formation periods are the most critical periods in terms of plant water consumption. Particular attention is paid to these periods, especially in regions where there is water shortage or supplementary irrigation, and at least it is expected to increase yield and quality with support irrigation activities.

Two different ways are followed in the determination of evapotranspiration. These:

- Direct measurement methods

- Forecasting methods using climate data

Direct measurement methods give healthier results. However, they are more expensive and time-consuming methods compared to the methods using climate data. In the determination of plant water consumption, generally higher correlations can be detected with the internal water state of the plant located in the middle of the soil-plant-water-atmosphere system.

3.2.11.1. Direct measurement methods of Evapotranspiration

Leaf water potential, transpiration rate and stomatal conductivity measurements will be used to determine **evapotranspiration** with the help of plant physiological parameters.

3.2.11.1.2. Leaf water potential (LWP) measurements

Pressure chamber device will be used in leaf water potential measurements. Pressure chamber technology continues to attract great attention as water resources expand. Although the technology has been around for years, walnut growers' interest has increased as the Pressure chamber has become the standard method for plant-based irrigation decisions in the orchard. Measurements are made before irrigation and at noon (12:00-14:00) when the sun's rays are perpendicular to the earth. In the measurements, leaves in the shaded part of the crown of walnut trees are used. Gas leakage from the pressure chamber is prevented by choosing the appropriate gasket when attaching the leaf to the pressure chamber. The leaf chosen for water potential measurement is cut off, its stem is cut and the leafy part is closed inside the room. Pressure is applied until water appears on the cut surface. When the cut surface is covered with water, the pressure reading is recorded as LWP (Schollander et al. 1964).

3.2.11.1.3. Transpiration rate

Plant-induced transpiration cannot be measured directly, but can be determined indirectly by measuring the reduction in mass due to water loss or the volume of absorbed water. The porometer is used to measure the rate of transpiration in proportion to water intake. Transpiration rate is calculated by measuring the distance traveled by an air bubble in a given capillary tube. Bubble motion is used to determine the rate of water uptake. The rapidity of the bubble movement indicates the higher the on rate. During the study, the transpiration rate will be determined by the hand-held porometer. It will be tried to determine the relationship between the measurement values performed with the porometer and seasonal crop water requirement.

3.2.11.1.4. Stoma resistance

Since stomatal resistance or conductivity is related to stomatal space and transpiration, it can be used as an indicator to determine the water requirement of the plant. Generally, a high resistance is an indication that the stomata are significantly closed. As a result, the rate of transpiration slowed down. It is understood that the rate of transpiration slows down and it is time to water the plant.

Measurements of the data related to the transpiration rate and stomatal resistance will be made by taking 48 measurements from 2 plants for each irrigation, at 10:00-12:00 hours before irrigation, from healthy leaves that receive full sunlight (Salbaş, 2020).

Most measurements on the soil-plant-atmosphere continuum are simple. However, measuring stomatal conductivity is relatively more difficult. Since stomatal conductivity cannot be predicted from theory, it must be measured directly. In this respect, it is extremely important that the measurement processes can be done with an easy tool. In the research, stoma resistance will be determined with the help of a porometer device as well as transpiration rate.

Since stomatal resistance is related to the degree of stomatal spacing and transpiration rate, it is used as an indicator to determine the water requirement of the plant. Generally, high resistance indicates that the stomata are significantly closed, the rate of transpiration is reduced, and the need for water. Stomatal resistance and conductivity are opposite of each other. Commercial leaf or diffusion Porometers are used to measure stoma resistance (Şen and Gündüz 2018).

3.2.11.2. Forecasting of evapotranspiration using climate data

Since direct measurement methods are expensive and time-consuming, it is preferred to determine the evapotranspiration by using climate data. Many methods have been developed for this purpose. Class A Evaporation Pan is one of these methods.

3.2.11.2.1. Class A Evaporation Pan Method

As it is known, there is a very high relationship between evapotranspiration and evaporation from the open water surface. Using this relationship, the A class evaporation pan method has been developed as an easy, quick and accurate method (Anonymous, 1986.). Class A Evaporation pan should be located near the Walnut orchard.

Class A evaporation vessels used in practice; They are open cylindrical containers with a diameter of 121 cm, a height of 25.5 cm, made of galvanized sheet, painted with aluminum paint. The Class A Evaporation pan is placed on a wooden pallet 15 cm above the floor. For this purpose, a 5 cm thick filling is made on the land surface and a 10 cm thick wooden pallet is placed on it. After the wooden scaffold is placed, the container is seated. Thus, wind circulation is provided from all directions. For accurate measurements, the container must be placed exactly horizontally. A thermometer and anemometer should also be provided for temperature and wind speed measurements. The water changes in the evaporation pan can be measured with a micrometer depth measuring device with an accuracy of 1/100 of a millimeter. In order to prevent fluctuations on the water surface during reading, the instrument is placed inside a steel cylinder. In order for the water to enter the cylinder easily, it is placed in the A class evaporation pan on 3 legs. The water filled into the container should be 5 cm below the surface. After the water in it is allowed to evaporate for a maximum of 2.5 cm, water should be added to the old level again. The aim of this is to reflect the effect of wind on evaporation in the healthiest way possible. If the container is in an open field, it should be covered with cage wire in order to prevent wild animals from drinking water. The container should be cleaned by changing the water once a week against algae and sedimentation.

3.2.12. Vegetative Growth Parameters and Yield

During the research, as vegetative growth parameters for walnut;

- Crown height,
- Crown width and
- Trunk thickness selected.

The crown width and crown height values will be measured with the help of the surveyor's rod when the trees go to winter rest at the end of the irrigation season. The measurement trees in the trial plots will be marked as the measurement point 15-20 cm above the grafting points. At the time of the experiment and at the end of the irrigation seasons, when the trees enter winter rest, trunk diameter measurements will be made from the marked places using caliper. Trunk cross-sectional area values of walnut trees will be calculated using trunk diameters. By subtracting the end of each irrigation season from the previous year, the amount of increase in trunk diameter and trunk cross-section area will be calculated (Erdem, 2018).

Yield measurements

During the trial, yield values will be determined and evaluated per tree and area. In order to determine the yield obtained from the trial subjects, the fruits will be separated from their green shells and dried after the harvest from the control trees in each trial plot. Yield values per tree and per ha will be calculated from dried fruits.

- Yield (kg/tree, kg/ha)

Chandler walnut tree has an average yield of 2-4 kg in the 4th year, 5-10 kg in the 5th year, 50 kg in the 10th year, and 100 kg in the 20th year.

3.2.13. Irrigation Water Usage Efficiency (IWUE) and Water Usage Efficiency (WUE)

It is defined as the rate of utilization of an existing opportunity as a beneficiary. Irrigation efficiency refers to the rate of utilization of the water source. For this purpose, there are indicators developed to measure efficiency at many different levels. Among these, two irrigation efficiency given below were chosen because they are two important indicators for water efficiency (Bos 1980).

- **Irrigation Water Use Efficiency (IWUE)**
- **Water Use Efficiency (WUE)**

Irrigation Water Use Efficiency (IWUE) to be used in the research will be used to calculate how much the walnut tree yields against each unit of irrigation water. Thus, the yield values against the irrigation water obtained in different irrigation water applications are compared and the most suitable irrigation program can be decided.

The water use efficiency, on the other hand, expresses the yield value for walnut against the plant water consumption. With this indicator, the effect of plant water consumption values obtained in irrigation issues on yield is examined.

With irrigation issues, not only will the trial plots be determined with the highest yield, but also the irrigation issues where the least yield loss will occur under water constraint conditions.

BIBLIOGRAPHY:

Anonim, (2012). Ceviz Eylem Planı 2012-2016. T.C. Tarım ve Orman Bakanlığı, Orman Genel Müdürlüğü, Ankara. 48s.

Anonim, (2017). Ceviz Entegre Mücadele Teknik Talimatı. T.C. Tarım ve Orman Bakanlığı, Ankara, 94s.

Anonim, (2020). Ceviz Bahçe Tesisi Projesi, Fizibilite Raporu ve Yatırımcı Rehberi. T.C. Tarım ve Orman Bakanlığı, Bitkisel Üretim Genel Müdürlüğü, Ankara.

Anonim, (2021a). Devlet Su İşleri [DSİ], Toprak Su Kaynakları. Erişim adresi https://www.dsi.gov.tr/Sayfa/ Detay/754

Anonim, (2021b). Tarım Ürünleri Piyasası; Ceviz. T.C. Tarım ve Orman Bakanlığı, Tarımsal Ekonomi ve Politikaları Geliştirme Enstitüsü, Ankara.

Erdem, T. (2018). Damla Sulama ile Sulanan Ceviz Ağaçları İçin Uygun Lateral Tertip Biçiminin ve Sulama Programının Belirlenmesi, Tekirdağ.

Fulton, A., Salinas, M., Montoro, A., Goldhamer, D. (2003). Evaluation of Trunk or Scaffold Shrinkage in Walnut As an İndicator of Orchard Water Status. California Walnut Board. Walnut Research Reports. http://ucanr.edu/repositoryfiles/2003_135_ocr.pdf-154326.pdf

Hu, Q., Ma, Y., He, J., Zhang, Q., Hong, M. (2010). Effect of Drip İrrigation and Micro –Sprinkler İrrigation on Water Consumption, Yields and Quality of Walnut. Journal of Water Resources and Water Engineering, 1:020.

Konukcu, F., Albut, S., Altürk B. (2019). TR21 Trakya Bölgesinde İklim Değişikliğinin Etkileri ve Uyum Stratejileri. Namık Kemal Üniversitesi. 207s.

Li, H.B., Mu Z.X, Hong M, Zheng B. (2013). Optimization of Irrigation Methods for Grown Walnut in Arid and Semi Arid Regions. Water Saving Irrigation, 6, 010.

Orta, A.H. (1997). Bağ Sulamasında Damla ve Karık Yöntemlerinin Ekonomik Yönden Karşılaştırılması. Tarım ve Köyişleri Bakanlığı, Tarımsal Araştırmalar Gn. Müdürlüğü Bağcılık Araştırma Enstitüsü Yayınları 151, Tekirdağ.

Salbaş, B. (2020). Bitkiye Dayalı Ölçüm Tekniklerinin Ayçiçeği Sulama Zamanı Planlamasında Kullanım Olanakları. Fen Bilimleri Enstitüsü (YL Tezi), Tekirdağ Namık Kemal Üniversitesi.

Saraoğlu, E. (2014). Arıtılmış atıksuların tarımsal sulamada yeniden kullanımı-ülkemiz ve dünyadan başarılı örnekler ve Türkiye için uygulama önerileri (Çevre ve Şehircilik Uzmanlık Tezi),

Project funded by EUROPEAN UNION

AGREEN Community for climate-smart agriculture

T.C. Çevre ve Şehircilik Bakanlığı, Çevre Yönetimi Genel Müd., Su ve Toprak Yönetimi Dairesi Başkanlığı.

Schollander, P.F., Hammel, H.T., Hemmingssen, E.A., Bradstreet, E.D. (1964). Hydrostatic pressure and osmotic potential in leaves of mangroves and some other plants. Proceedings of National Academy of Sciences (USA), 52, 119- 125.

Şen, A. ve Gündüz, A. (2018). Bağda Fizyoloji ve Stres Çalışmalarında Kullanılan Cihazlar. BAHÇE 47(Özel Sayı 1): Türkiye 9. Bağcılık ve Teknolojileri Sempozyumu: 31–36.

Şen, S.M. (2011). Ceviz. ÜÇM Yayıncılık, Ankara.

Ustin, S.L., Martens, S.N., Vanderbilt, V.C. (1991). Canopy Architecture of a Walnut Orchard. IEEE Trans. Geosci. Remote Sensing, 29: 843-851.

Yıldırım, O. (1996). Bahçe bitkileri sulama tekniği. Ankara Üniversitesi Ziraat Fakültesi. Yayın no1438. 188s.

Zhao, J., Hong, M., Ma, Y., Wang, C., Zhang, O., Zheng, B. (2010). Matured Walnut Water Consume under Different Micro-İrrigation Method. Journal of Irrigation and Drainage, 05.

The editor of the material: Tekirdag Namik Kemal University (T-NKU)

Address: Turkey, 59030, Süleymanpaşa, Tekirdağ, Kampüs Caddesi, No:1

Phone: +90 282 2502264

E-mail: terdem@nku.edu.tr, ddogan@nku.edu.tr

Website: www.nku.edu.tr

Joint Operational Programme Black Sea Basin 2014-2020
Tekirdag Namik Kemal University
December 2021
Joint Operational Programme Black Sea Basin 2014-2020 is co-financed by the European Union through the European Neighbourhood Instrument and by the participating countries: Armenia, Bulgaria, Georgia, Greece, Republic of Moldova, Romania, Turkey and Ukraine.
This publication was produced with the financial assistance of the European Union. Its contents are the sole responsibility of Tekirdag Namik Kemal University and do not necessarily reflect the views of the European Union.