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

SUPPLEMENTAL IRRIGATION APPLICATIONS IN SUNFLOWER GROWING

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

SUPPLEMENTAL IRRIGATION APPLICATIONS IN SUNFLOWER GROWING

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

Global climate change causes certain changes in our country as well as all over the world. Under the influence of climate change, an increase in temperature and a decrease in precipitation are expected in our country. When the climate data of the last 25 years are examined, the change in the temperature regime is clearly seen. Increases in temperature and decrease in precipitation also bring drought (IPCC, 2013). When the annual average temperatures of our country are examined, it is seen that the warmest years are experienced especially in the years after 2000. In the climate models made, it is stated that there will be an increase of 0.5-1,5ºC even in the most optimistic forecasting method in 2016-2040 in our country. Similarly, it is expected that there will be a decrease of up to 10% in precipitation, although it varies regionally. In our country, the Agricultural Drought Fighting Strategy and Action Plan have been put into practice, and the necessary measures to reduce the effects of possible droughts have been determined and institutions and organizations have been informed about this issue (TAGEM, 2020).

The increase in temperature and decrease in precipitation make the need for some strategic plans and preparations to be made in terms of agricultural production in the climate region we live in. When the water resources of our country are examined, it is seen that we are among the countries experiencing water stress. According to the World Resources Institute, Turkey ranks 32nd in the high groundwater stress list (Anonymous, 2021).

The sector where the effects of climate change will be seen the most is expressed as the agricultural sector. It is expected that there will be decreases in plant production in both rain-related and irrigated agricultural areas. It is necessary to change the way of production and to organize more productive systems for the effective use of water resources that are decreasing with the effect of increasing population and climate change. The decrease in the yield of plants that have strategic importance for our country, such as sunflower, under the influence of climate change, can only be eliminated by drought-resistant varieties, soil moisture preservation methods and irrigation activities. 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. In this case, it is thought that it will have a restrictive effect, especially in the production of summer products. Climate change brings with it an increase in the current irrigation water requirement. As a result of this situation, it is necessary to make optimal use of existing production facilities for a sustainable production.

With the climate change in the Thrace Region, it has been determined that there will be great losses in biomass and yield in sunflower, which is one of the most produced plants in the region. In the model studies, it has been determined that there will be negative effects on the grain yield of sunflower due to the increase in temperature and decrease in precipitation in the Thrace region.

Irrigation emerges as an essential input in agricultural production in the semi-arid climate region we live in. However, the reduction in water resources necessitates the use of drip irrigation method, which saves water in irrigation activities, in larger areas. Another factor is the water constraint and application time planning to be applied in limited irrigation activities. It should be aimed to achieve maximum efficiency in the current situation by carrying out irrigation applications to be made with the already scarce water resource during the periods when the plant needs water the most. The dominant plant of the Thrace region is the sunflower grown in rotation with wheat.

Two different types of sunflowers are produced in the world and in our country as oil and snack. The variety that is not consumed as oil is generally called as snack. Produced as a snack, sunflower is consumed as human and bird feed. Snack sunflower has a thick shell and a lower oil content. Oil sunflower is generally thin-shelled and naturally high in oil (38-50%) plants, unlike black-colored snacks (Kaya, 2021).

Sunflower is one of the most preferred plants in oil production due to its high oil content. Although its original homeland is Mexico, it is seen that sunflower production is made in most regions of temperate geographies. Most of the world sunflower exports are provided by Moldova, Serbia, China and Kazakhstan.

Vegetable oils are the most preferred oils in oil production in the world. Different kinds of plants are used to meet this need. In fact, in general, the most used vegetable oils in the world are soybean, rapeseed and sunflower. In our country, sunflower, olive oil and canola are mostly used in oil production. Sunflower is not only used as a raw material for cooking and oil production, but also for soap, margarine and paint production. In addition, residues after oil production in sunflower are widely consumed as animal feed.

According to the statistical calculations made considering the increasing world prices, it is estimated that Turkey's foreign trade deficit for sunflower will be 637 million dollars on average in 2030. It is statistically estimated that our sunflower oil imports in 2014/15, whose value was 1.1 billion dollars in the current conjuncture, will increase to an average of 2.5 billion dollars in 2030/31 (Güleş et al. 2016).

In order to meet the current vegetable oil need in Turkey, it is essential to break the dependency on foreign sources and increase production in order to be self-sufficient. Sunflower will be in a better position in the eyes of the farmers by increasing the lands where sunflower production is made and by increasing the yield per unit area. In order to increase the average yield per decare, it is extremely important to increase the yield with professional agricultural techniques, as well as to give importance to research and development of varieties with good yields in different locations (Özdemir and Sinan, 2020).

The inability to provide sufficient production against the demand experienced in sunflower oil reveals that some inputs and techniques are not used adequately in production. When the cultivation areas are examined, it is seen that the natural limits for sunflower have been reached in terms of land availability. In this case, in order to meet the current demand, it has become a necessity to select high-yielding and resistant varieties, to apply appropriate fertilization and soil cultivation, to implement agricultural control and crop rotation, as well as to carry out an irrigation application in accordance with the technique. Although it has a pile-rooted structure, the fact that sunflower is a summer plant causes the plant to not reach enough water during the growing period and decreases the yield. It is known that large increases in yield can be achieved with conscious irrigation for sunflowers produced in summer in regions with low rainfall (Süzer, 2008).

Sunflower production in our country started in the first years of the republic and has an increasing production area in the following years. When we look at our country, it is seen that the production areas of sunflower are mainly in Thrace, Marmara, Central Anatolia, certain regions of the Black Sea and Çukurova regions. The cultivation areas in the Thrace region are listed as Tekirdağ, Edirne and Kırklareli. Although Thrace is an important place in terms of sunflower production area, it makes a great contribution to oil sunflower production in the Konya region, which has less production area, because it produces under irrigated conditions (Anonymous 2012). This situation reveals the role of irrigation in removing the available deficit in sunflower production in irrigated conditions.

When the water resources of our country are examined, it is known that we do not have enough usable water resources for the existing agricultural lands. Since our country is located in a semi-arid climate zone, it is extremely important to develop our water resources in terms of quality and quantity. Since the average precipitation in our country is 574 mm, it has a water cycle of approximately 450 billion m^3 per year. Currently, 112 billion m3 of this existing water is in usable form, of which 94 m3 is from aboveground and 18 m3 is from underground sources. However, we currently use only 57 billion m3 of our usable water resources. In order to meet the increasing water need, we need to develop our existing water potential and put this water in use for agricultural irrigation purposes.

In addition to climate change, the population of our country is increasing rapidly every year. According to the data of the Turkish Statistical Institute, the country's population is expected to reach 100 million in 2030. The realization of this forecast means that the current annual per capita water amount will decrease from 1,600 m3 to 1,000 m3. In this case, Turkey will be among the countries suffering from water shortages. This will result in an increase in the amount of urban water consumption, which is one of the largest water user sectors in the country, as well as an increase in industrial water use and less water availability for agricultural water use.

Currently, 72% of our existing water resources are used for agricultural irrigation. In order to meet the increasing irrigation water need, it is essential to increase the efficiency of water transmission, distribution and application in irrigation works. In this respect, it is important to apply pressurized irrigation systems that ensure effective use of water. Likewise, in order to get maximum efficiency from the unit water by using the water more efficiently in the field plot, drip irrigation method applications should be rapidly expanded and applied to all irrigation areas.

2. OBJECTIVES AND TARGETS OF THE RESEARCH

In our second model, which will be prepared to reduce the effects of climate change, our aim is to increase farmer welfare by minimizing the effects of drought and to realize sustainable sunflower production.

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

Target 1. Maximizing efficiency and ensuring a sustainable production with minimum irrigation water

Target 2. To determine the most suitable support irrigation plan for the sunflower plant grown in the region.

Target 3: Determination of the most suitable irrigation scheduling for sunflower

Target 4: To reveal the possibilities of using leaf water potential, transpiration rate and stomatal conductivity measurements for plant-based irrigation scheduling planning.

3. MATERIAL AND METOD

3.1. Materiel

3.1.1. Cultivar

In this research, it is aimed to maximize the yield with minimum irrigation water in the sunflower plant, which is widely grown in our region, but we are dependent on foreign sources, especially due to insufficient production in oil production.

3.1.1.1. General characteristics of sunflower

Sunflower is a field plant with good adaptability, can be grown in rainfed conditions, and higher yield and quality can be achieved if irrigated conditions are provided. Sunflower, which is a plant that can be cultivated with extremely simple techniques as an agricultural technique, has a very wide cultivation area. Although the growing conditions of sunflower are relatively low, it is one of the most preferred oil plants due to its high oil content. Although the vegetation period varies according to the region and variety, it varies between 80-130. In the Thrace region, sunflower is planted between mid-April and early May. Harvest takes place in September.

One of the most important parameters affecting the yield in sunflower production is the seed. It is observed that there has been an increase in the use of hybrid seeds, especially after the 1980s.

As in the rest of the world, a great improvement in yield and quality has been achieved in sunflower with hybrid seeds in our country

Sunflower growth stages are divided into two phases. These stages are called vegetative and reproductive stages. Vegetative stages consist of four stages. The reproductive stages consist of 5 stages, from the first stage when the flower head begins to form to the harvest.

It is necessary to divide the yield evaluation in sunflower into two as rainfed and irrigated conditions. As a result of some researches, it has been determined that while an average yield of 150-160 kg/da is obtained in arid conditions, 225-250 kg/da can be obtained when irrigated once and 350-400 kg/da when irrigated twice (Süzer, 2021). Especially in the Thrace region, which is rainy in May-June, yields of 400 kg/da can be seen (Güleş et al. 2016). This situation shows how important irrigation activity is on yield, whether full irrigation or supplemental irrigation.

3.1.1.2. Climate demand of sunflower

Sunflower is a tolerant plant in terms of climate demand. It can be grown especially in temperate and continental climate regions in our country. In regions where late spring frosts are experienced, sunflower shows resistance to this frost. Sunflower can withstand temperatures as low as -5ºC during the period when its first leaf emerges. However, this resistance gradually decreases towards the period when the number of leaves of the sunflower is 6-8.

Sunflower is a plant that is partially resistant to drought, especially in regions with high temperatures, due to its strong and deep root structure.

Irrigation applications are recommended to increase yield in arid regions. Sunflower, which is grown as an annual and summer plant, can be grown in places where the average temperature in July does not fall below 18-19ºC. The total temperature requirement of the sunflower is 2600-2850ºC. During germination, it is desirable that the temperature should not fall below 4-5ºC. However, the temperature should be above 9-10oC in order not to decrease the germination performance. On the other hand, it is undesirable for the temperature to rise above 40oC, since extreme temperatures have a negative effect on pollen (Tan, 2007).

3.1.1.3. Soil requirement of sunflower

Sunflower likes deep soils due to its deep roots. For a good root development, the soil pH should be between 6-7. It grows well in salty soils compared to soybean, rice and corn. It grows well in soils with high soil moisture, high water holding capacity and rich in organic matter. It prefers non-acidic soils. In general, it can be grown in any type of soil that is not very heavy, sandy and acidic. They develop well in humus and alluvial soils. In order for sunflower to germinate, they have a demand for soil temperature of 8-10oC. It is beneficial to break the plow base layer at a depth of 50-60 cm with a subsoiler every 4-5 years.

3.1.1.4. Suitable sunflower varieties for the region

Increasing the yield in sunflower production emphasizes the use of more resistant varieties against existing diseases and pests. In recent years, a significant increase in the use of hybrid sunflower varieties has been observed. However, the performance of hybrid cultivars is completely dependent on the growing conditions. In order to get full performance from hybrid varieties, it is necessary to meet the maintenance, fertilization and irrigation water needs of the plant completely. Another problem is that while the farmer can produce his own seed with the production of patriarchal seeds, such a situation is not possible in hybrid seeds. Since the sunflower plant is a foreign pollinated plant, the farmer has to buy new seeds every year. There are about 60 sunflower varieties in our country. In addition to domestic breeds, varieties of Pioneer and LG companies that are resistant to broom-rape and mildew diseases are preferred.

Currently, there is no variety problem in sunflower, there are varieties resistant to orobanche and downy mildew, which are the most important problems in sunflower production. Today, although the varieties of many international companies in the sunflower seed sector are sold in the market in our country, the number of varieties belonging to domestic public and private companies has been increasing in recent years (Kaya, 2016).

3.1.1.5. Planting

Since sunflower has the opportunity to plant in a very wide area in our country, sowing dates are carried out in a wide range from mid-March to July. For a good sowing, the seed bed must be tempered. Sunflowers are planted in the Thrace region in April. However, in rainy periods, this date extends until May. Sunflowers are planted in rows. n order for the row spacing to be sufficient for tillage activities after planting in sunflower, planting should be done with 30-50 cm intrarow and 70 cm row spacing. Frequent planting negatively affects plant growth and causes a decrease in yield. A similar situation applies to unnecessary sparse plantings. In this case, the total production decreases as the number of plants decreases. Plant rows should be planned parallel to the prevailing wind direction in the region in order not to face the problem of tilt on the sunflower. Sunflower planting depth is around 4-6 cm. If the soil is tempered, 3-4 cm depth is sufficient. Deeper planting may cause germination problems. For sowing, 500-600 g seeds are used per decare with a pneumatic seeder, and 1500-2000 g seeds are used in case of standard drill.

Soil temperature is required to be 8-10oC at the time of sowing in order to avoid problems in germination and emergence. The fact that the soil is tempered represents the optimum time both in terms of moisture content and soil temperature. It will be seen that the amount of energy to be spent for tillage during planting in the tempering will also be positively affected.

The sunflower plant emerges after an average of 7 days after planting. After 15-20 days, it reaches the height to thin. After 25-35 days, it is time to fill the root collar, and after 60-75 days, it coincides with the flowering period. While the sunflower plant reaches physiological maturity after approximately 85-120 days, it is harvested after 90-130 days

3.1.1.6. Tillage in sunflower cultivation

In the field where sunflowers will be planted, the soil should be plowed from a depth of 20-25 cm with a plow in the autumn period and left to rest. It is recommended to plow from a different depth every year so that the plow pan does not form while the soil is being cultivated with the plow. With one hundred more tillage, the cost will also be reduced. Spring tillage will help to easily enter and store precipitation waters in the lower soil layers through the crevices created in regions where it is rainy in winter.

If weed emergence is observed at the beginning of winter after the autumn plowing, it is recommended to process from 10-15 cm with crowbar. It will be beneficial to plow the weeds that have emerged since autumn before the planting period in April-May in the spring, with a crowbar or disc harrow, from a depth of 8-10 cm. Making deep plowing during this period will cause the soil to lose its temper. To prepare the seed bed, the soil plowed with a crowbar or disc harrow can be worked with a rake or coulter.

In areas where planting is not done with a combined seeder, fertilizers are scattered on the soil with a centrifugal fertilizer machine. In case of weeds in the field, disinfection can be done in the same period. Disc harrow or harrow can be used to mix the discarded fertilizer and pesticide into the soil. The soil is pressed with the slider and the soil becomes ready for planting.

Sunflower is a hoe plant. Hoeing is extremely important in terms of weed control, swelling of the soil surface, moisture preservation, and high yield. Hoeing for sunflower is generally done in two periods. The first of these is hoeing without going too deep when the plant reaches 10-15 cm tall. Plants with irregular emergence should have been thin in plantings that are not made with precision sowing machines. During the thinning process, using crowbars, the soil duff layer is broken between the rows, the soil is swelled and weeds are cleaned. When the plant reaches around 25-30 cm, the second hoeing process is applied. Thanks to the hoeing done in this period, weed control as well as the filling of the root neck is done. By filling the root collar of the sunflower, the soil in the root zone remains annealed for a longer time, the plant is prevented from lying in the irrigated areas, and the fight against the emergence of weeds in the area close to the root zone is prevented. If deemed necessary, another hoeing is carried out before flowering.

3.1.1.7. Fertilizer needs of sunflower

Fertilization is the application of the nutrients needed by the plant to the soil or directly to the leaves of the plant at the desired amount and time. Especially in organically weak soils, fertilizer is one of the inputs that directly affects the yield. In order for the fertilizer application to be applied efficiently, first of all, soil analyzes should be made and the amount of available nutrients should be determined. Then, it will be beneficial to apply fertilizers based on plant needs. It is recommended to be done together with irrigation in order to reduce the workload and cost in fertilization applications and to increase the efficiency of fertilization.

For fertilizer application in sunflower, the amount of fertilizer that can be given roughly in a land where soil analysis has not been made varies depending on the application of the fertilizer in irrigated and unirrigated conditions or in pure or composite form. If the planting area has unirrigated conditions, 7-8 kg/da N, P, K application is recommended. In irrigated conditions, this amount should be increased up to 10 kg/da to eliminate the effect of washing. In the case of compound fertilizer application, 20-20-0 or 15-15-15 fertilizer can be applied. The entire nitrogen fertilizer can also be given as a compound fertilizer before planting. If sowing will be done with a combined sowing machine, fertilizers are applied to a depth of 10-12 cm in bands (Tan, 2007). In case of lack of sufficient nutrients in the soil in sunflower, it can be understood by the spots of different colors on the leaves. Deficiencies of elements such as potassium, magnesium, iron and manganese can be detected by examining the defects in the leaves

If the use of animal manure is planned to meet the fertilizer need, 3-4 tons of farm manure per decare is appropriate in the last spring period. Thanks to the use of farm manure, productivity increase is supported and at the same time, it supports the improvement of the organic structure of the soil.

3.1.1.8. Crop rotation

Crop rotation (alternation) is a different application area of multiple production systems. Crop rotation; It is the cultivation of crop plants of different species on the same agricultural area, one after the other at regular intervals, by rotating them. Due to the fact that sunflower takes more nutrients from the soil, it is necessary to improve the soil structure in order to obtain high yields, as well as to keep diseases, pests and parasitic plants under control. In the rotation system applied in the Thrace region, it is carried out in the form of sunflower-wheat in rainfed conditions. Forage crops can also be included in the rotation in this region. In regions where irrigated agriculture is carried out, it can enter crop rotation with corn, soybean and beet.

3.1.1.9. Controlling diseases, weeds and pests

One of the biggest problems in the Thrace region, where sunflower production is the most, is the Orobanche parasite plant. A fully parasitic weed, Orobanche does not have green leaves. Therefore, its life depends entirely on the food it receives from the plant it is host to. Precautions can be taken by cultivating varieties that are resistant to the orobanche species of the region. On the other hand, removing the orobanche from the field, especially before the flowering period, can prevent its seeds from entering the soil and causing problems for the grower in the following years. In the field plots where this parasite is seen, it is recommended to switch to sunflower planting after 4-5 years of alternation with plants that are not hosts of this parasite (wheat, sugar beet, corn, clover, etc.). In addition, it is recommended that the field be plowed deeply before sowing, planted resistant sunflower seeds, and since the seeds can stay alive in the soil for a very long time, they should be plucked by hand and burned in a separate place before the seeds are formed (Anonymous, 2012).

Another problem for sunflower is the mildew disease. Varieties resistant to this disease have been developed and are currently in use. By using these varieties, high yield and oil production can be guaranteed.

3.1.1.10. Irrigation and irrigation water requirement of sunflower

Sunflower is known to have the ability to take water even from very deep thanks to its deep structured roots. Although it is ranked among the plants with high drought resistance, in regions where drought lasts for a long time, especially the seed setting rate remains low and yields are severely reduced.

When sunflower cultivation is examined, it is seen that the most important factor affecting yield in our country is irrigation. In regions such as Thrace, where there is not enough rainfall to meet the plant water need, irrigation is essential for our country to reduce the need for imports and even to terminate the import completely. Insufficient water resources in general of the production areas of sunflower in our country, decreasing water resources due to the effects of climate change and increasing the yield can only be achieved with an effective irrigation program. With the support irrigation studies carried out in recent years, it is aimed to increase the yield of sunflower and to make optimum use of the existing water resources. At this point, it is extremely important how much and in which periods the water should be applied in limited irrigation applications.

When we look at the country in general, the amount of precipitation, especially during the plant development period, is considered sufficient to meet the plant water consumption. However, studies have shown that irrigation activities carried out during critical development periods of sunflower have been found to be extremely effective in the yield of hybrid varieties. Sunflower uses 20% of its crop water requirement in the period from emergence to the stage of table formation. When the development periods for sunflower are examined, it is stated that the stage formation-flowering period is the most critical. It is stated that with the support irrigation activities to be carried out during this period, the decrease in yield in dry periods can be prevented with a low cost and workload (Tan, 2007).

In fact, in regions where the annual precipitation is above 500 mm, sunflower production can be carried out without the need for irrigation water. However, it is seen that there is a decrease in yield in such cultivation areas. If there is a sufficient water source for irrigation in these regions, irrigation activities are recommended in terms of increasing grain yield and oil rate. Studies show that sunflower, which has a yield of 150-160 kg/da in dry, has been shown that the yield can be increased up to 350-400 kg/da with the support irrigations to be carried out in dry and critical periods (Suzer, 2008).

In sunflower cultivation, an average of 450-800 mm of irrigation water during the growing period will help to get the maximum yield. The highest water demand for sunflower is 20 days before flowering and 10 days after flowering period. In general, if the season will be completed with a single irrigation, it should be done at the beginning of flowering. If two irrigations are planned, the first one is recommended to be done during the flowering period when the diameter of the crown reaches 4-6 cm (Anonymous 2012). Among the methods that can be applied for sunflower are sprinkler, furrow and drip irrigation methods. In order to protect water resources, drip irrigation method comes to the fore among these methods. With the drip irrigation method, the plant stays less under stress conditions and increases the yield and quality.

3.2. Method

3.2.1. Study area

Viticulture Research Institute located in Tekirdag province was selected for this study to be carried out with sunflower. The research institute is located in the district of Süleymanpaşa in Tekirdag province. The height of the research area from the sea is 4 m. The Institute has 979 da of agricultural land in total. The research area is located in the semi-arid climate zone. In the research area, where the annual average temperature is 14.1oC, the hottest months are July and August. The average annual precipitation in the region is 580 mm. The annual average relative humidity is 77%. The research area is at 40°59' north latitude and 27°29' east longitude.

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.

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

During the research, it is planned to use wells as a water source as stated above. The use of well water in the drip irrigation system is very risky due to the sediment they contain. Sediment and similar objects cause clogging of the drippers, which are the most important parts of the system. Therefore, resting the water source is extremely important. Irrigation water resting in the pools can be given to the system after it is separated from the foreign substances it contains. However, foreign materials transferred to the system still need to be disposed of with the hydrocyclone, sand-gravel filter tank and disc filter located in the control unit. The drip irrigation system provides the transportation of water with 6 atm operating pressure, 50 mm outer diameter rigid PE pipes. The manifolds in the research area consist of 32 mm outer diameter soft PE pipes. The lateral pipeline consists of soft PE pipes with an outer diameter of 16 mm. The dripper flow rate will be determined depending on the soil infiltration rate. In addition, it will be determined as a result of the infiltration rate tests whether to lay one lateral on each row or one lateral on two rows. The spacing of the drippers will also be determined at the beginning of the season. Drippers are planned to be procured online.

3.2.5.1. Pump and Control unit

After eliminating the pressure loss caused by the equipment and pipes used in the drip irrigation system in the irrigation area, it is essential to use a pump that can meet the pressure and flow rate required for operation. The power source of the pump used in the system is related to the availability of energy. While the electrical energy near the system means that the pump is operated with an electric motor, pumps using gasoline, diesel or electrical energy are used as an alternative at points where there is no access to electricity. (Lightning, 1996). In this study, water will be pumped into the system with a gasoline engine.

The water pressed into the system from the pool by the pump, the necessary filtration, fertilizer and pressure controls are carried out in the control unit. It is planned to use hydrocyclone, sand-gravel filter, fertilizer tank, disc filter and manometers in the control unit used during the study. The equipment that is planned to be used in the control unit is explained below.

3.2.5.1. Hydrocyclone

Hydrocyclone is the first filter element used in the control unit to separate solid components in irrigation water. It is widely used because of its simple working principle, ease of installation and low cost. High capacity versus low energy consumption is one of the reasons for preference. Hydrocyclone is especially used in the treatment of sandy irrigation waters, where irrigation water is drawn directly from rivers, lakes or wells.

The hydrocyclone consists of a lower conical section, an upper discharge pipe and a lower discharge pipe. The hydrocyclone has an inlet and an outlet connected to the upper part of the cylindrical part. The flow enters the hydrocyclone tangentially in the cylindrical upper region, which creates the centrifugal acceleration inside the Hydrocyclone. Therefore, the fluid pressure height of the feed stream is converted into rotational motion. The downward flow moves close to the wall, while the upward flow moves close to the central axis. Meanwhile, with the slowing of the flow, heavy foreign materials such as sand in the water are removed from the system by falling down with the effect of gravity.

3.2.5.2. Sand-Gravel Filter Tank

Although the sand and similar parts entering the system are kept in the hydrocyclone, the unfiltered parts still threaten the system. Sediment and suspended foreign substances entering the irrigation system should be prevented from entering the system so that they do not clog the drippers. With the sand-gravel filter to be added to the control unit after the hydrocyclone, sediment and suspended solids are kept by the sand-gravel filters. Water enters the sand and gravel filter from the upper part, and the water passing through the sand and gravel layers in the tank provides exit from the lower part of the tank. While the sediment and suspended solids move through the sand and gravel, a filtration similar to the underground water is tried to be carried out in the natural environment.

3.2.5.3. 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.

3.2.5.4. 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.

3.2.5.5. 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.

3.2.5.6. 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

If there is sufficient water source, furrow, flood, sprinkler or drip irrigation methods can be applied as irrigation method. However, especially in regions such as the Thrace region, where surface water resources are used uncontrollably and where groundwater is decreasing day by day, irrigation with pressurized irrigation methods is a must. In this case, sprinkler and drip irrigation methods, which are pressurized irrigation methods for sunflower, can be used. However, the application of the sprinkler irrigation method during the flowering period of the sunflower plant has a negative effect on pollination, and it is not recommended to use the sprinkler irrigation method in regions where diseases are common. In this case, it has become a necessity to choose the drip irrigation method as the irrigation method.

Drip irrigation method was chosen for sunflower support irrigation. The basis of the drip irrigation method is to give a small amount of irrigation water to the soil in the plant root zone at frequent intervals in order to prevent the lack of moisture in the soil and the stress that may occur in the plant.

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.

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.

3.2.7. Applications of Irrigation Water

In this experiment, which is planned to be made with sunflower, the effects of supplemental irrigation applied in different periods on sunflower yield will be investigated. The research subjects to be applied during the research are given below.

I_1: Trial subject without irrigation water, control trial subject with rain-based cultivation

I_2: Trial subject in which support irrigation is applied during the flowering period

I_3: The subject of the experiment in which support irrigation is applied in fruit formation

No irrigation application will be made in the I_1 trial subject and it is applied as a control group for the purpose of comparison of irrigation subjects. Two irrigation applications are planned during the research, the first of which is I_2.

In the subject of I_2, the irrigation water needed by the sunflower plant during the flowering period is applied. On the subject of I_3, it refers to the subject where the irrigation water needed by the sunflower is applied in fruit formation. The soil moisture value in the sunflower planted plots will be determined by the gravimetric method during the flowering and fruit formation cycles and the calculated irrigation water amount will be applied to the plant by the drip irrigation method. 3 blocks will be created in the trial area and there will be 9 parcels in total, 3 in each block. Each trial plot is planned to be 4.2x6.0 m. It is planned to have 6 plant rows in each trial plot. The row spacing for sunflowers in the plots is 0.7 m and the intrarow is 0.3 m. In order to eliminate the edge effect in each plot, one plant row will be excluded from the trial.

3.2.8. Agricultural Technique

Soil preparation will be done with lister and disc harrow before planting in the research area. Except for irrigation applications, all agricultural techniques will be applied in the same way in research subjects. Fertilizer needs of all plots will be determined according to soil nutrient analyzes to be made before the experiment. In our region, nitrogen and potassium fertilizers are applied for sunflower in general. Sowing will be done with 70 cm between rows and 30 cm on rows. Weed control will be determined by field controls during the trial period. Thining and earthing up made with the exit after sowing will be applied.

Sunflower reaches harvest maturity 90-130 days after sowing. The flowers on the head of the leaves are dry and falling off in the plant at the time of harvest. In addition, when the harvest time came, the head left the yellow color and got brown with the effect of drying. Harvesting in oil sunflower is carried out with a combined harvester.

3.2.9. Evapotranspiration

Evapotranspiration is a critical parameter that must be accurately determined for irrigation time planning. **Evapotranspiration** can be determined in two different ways. The first of these are direct measurement methods, tanks and lysimeters, field trial plots, control of moisture reduction in the soil or measuring the flow in and out of the basin in basin-based measurements.

Direct measurement methods give healthier results. These methods are more expensive and time consuming than the methods using climate data. Studies are generally carried out in the form of plant-based and measurement of soil moisture value. In the determination of **evapotranspiration**, higher correlations can be detected with the internal water state of the plant located in the middle of the soil-plant-water-atmosphere system.

3.2.9.1. Crop-based measurement methods

In this study, it is aimed to reveal the relationship between the measurements to be made directly on the plant and evapotranspiration, and with the correlation between them, the farmers can make irrigation time planning with direct plant-based measurements without the need for soil moisture value. Leaf water potential, transpiration rate and stomatal conductivity measurements will be used to determine plant water consumption with the help of plant physiological parameters.

3.2.9.1.1. Leaf water potential (LWP) measurements

Pressure chamber device will be used in leaf water potential measurements. Measurements are made before the irrigations to be made during the flowering and fruit formation periods of the sunflower and at noon (12:00-14:00) when the sun rays come perpendicular to the earth (Salbaş,2020). In the measurements, the uppermost, sun-facing, fully developed leaves of the sunflower plant 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 value read is recorded as LWP (Hisio, 1993).

3.2.9.1.2. 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.

3.2.9.1.3. stoma resistance

Since stomatal resistance or conductivity is related to stomatal openness 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 transpiration rate slowed down. The slowing of the transpiration rate indicates irrigation time came.

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.

Measurements of the data related to the transpiration rate and stomatal resistance will be made by taking 36 measurements from 2 plants for each irrigation, from 12:00-14:00 hours before irrigation, from healthy leaves that are fully exposed to sunlight.

3.2.9.2. Evapotranspiration measurement by gravimetric method

In the gravimetric method, moisture determination is made with soil samples weighing approximately 100-150 gr with a soil auger for 30 cm depth, depending on the effective root depth of the plant. After the wet weight of the sample taken is weighed, it is left to dry in an oven at 105 ºC for 24 hours. Here, it is expected that the target soil will be completely removed from moisture, which is defined as oven dry, and only soil grains will remain. According to the wet and dry weight values obtained from the sample taken, the soil moisture value can be calculated in terms of dry weight percentage. The difference between this value and the field capacity obtained from the same plot is considered as the irrigation water requirement. Evapotranspiration for the season is determined by measuring the amount of moisture and precipitation regularly during the season.

In irrigation applications, the size of the moisture deficit in the soil, in other words the amount of irrigation water to be given to the plant, should be measured exactly. Although there are many different sensitive, difficult and costly methods developed for soil moisture measurement, the most widely used is the gravimetric method.

In the gravimetric method, the soil moisture value can be measured very precisely. However, determining the soil moisture with this method is a time-consuming method besides requiring extra labor. For this reason, the gravimetric method is used for calibration purposes in determining plant water consumption with other indirect methods due to its sensitive measurement capability.

3.2.9.2.1. Soil moisture constants important for irrigation

In order to determine the effectiveness of irrigation practices carried out during the irrigation season, the amount of water used and usable by the plant should be determined. In this regard, important soil moisture constants, Saturation point, Field Capacity and Wilting Point and Oven Dry should be determined in terms of irrigation.

3.2.9.2.1.1. Saturation point

saturation point refers to the conditions in which the soil pores are completely filled with water. Theoretically, it is expected that all the pores are full, but in reality, this is not possible. In real conditions, about 5-10% of the space between the soil voids remains empty due to the soil structure.

3.2.9.2.1. 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 m^2 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).

3.2.9.2.1.3. 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).

3.2.9.3. 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 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. While each soil has different amounts of usable moisture, each plant has a different tolerance to water. Therefore, irrigation activity should be carried out after a certain amount of usable water holding capacity is consumed. In general, 50% of usable water for field crops is allowed to be consumed. This value is 0.30 in drought sensitive plants and up to 0.75 in resistant plants. It is recommended to start irrigation activities when 50% of the usable water holding capacity is consumed for sunflower.

3.2.9.3.1. 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. Vegetative Growth Parameters and Yield

As vegetative growth parameters for sunflower during the research.;

- Plant height,
- • Plant stem diameter,
- • Head diameter,
- • Grain yield,
- • Thousand grain and hectoliter weights,
- • Dry matter content will be examined.

In each trial plot, measurements will be made from sunflower plants in the control area, without considering the edge effect. Measurements of plant heights during the trial will be carried out at the end of the season with the help of a levelling rod before harvest. It is planned to measure sunflower stem diameter with the help of a caliper 5 cm above the soil surface.

After the sunflower is harvested, the measurements of the heads brought to the laboratory will be carried out. Diameter measurements of sunflower head in the laboratory will be done with the help of caliper. Afterwards, the grains will be manually sorted and weighed and the parcel grain yields, thousand grain and hectoliter weights will be determined.

3.2.11. 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 Usage Efficiency (IWUE)**
- **Water Usage Efficiency (WUE)**

Sunflower is an important plant grown in arid and semi-arid regions because it is more drought tolerant. Sunflower is generally exposed to irregular precipitation regime in the regions where it is grown. Therefore, the average yield is relatively lower. Irrigation studies to increase yield are extremely important in terms of both protecting water resources and increasing efficiency. Irrigation water use efficiency (IWUE) to be used in the research will be used to calculate how much sunflower yields against each unit of irrigation water. Thus, the yield values against the irrigation water carried out in different periods are compared and the most suitable irrigation program can be decided.

The Water Use Efficiency, on the other hand, expresses the yield value received for the plant water consumption for sunflower. With this indicator, the effect of plant water consumption values obtained from two different irrigation subjects on yield is examined. In the case of limited irrigation with supplementary irrigation carried out in two different periods of sunflower, it will be tried to reveal that the most accurate result in terms of productivity will be achieved in which period the farmer makes the scarce irrigation water in his hands.

REFERENCES

Anonim, (2012). Bitkisel üretim çiftçi rehberi. Konya Şeker. Konya. 132s.

Anonim, (2021). Erişim adresi https://www.wri.org/insights/17-countries-home-one-quarter-worlds-population-face-extremely-high-water-stress

Bos, MG (1980). Irrigation efficiencies at crop production level. ICID Bull. 29: 18-25.

Delibaş, L. 1994. Sulama. Trakya Üniversitesi Tekirdağ Ziraat Fakültesi Yayınları No.213, Ders Kitabı No. 24, Tekirdağ

Gardner, W.R., 1967. Delevelopent of Modern Infiltration Theory and Application in Hydrology. Transaotions of the ASEA, Vol. 2.

Güleş, H.K., Özgüven, M., Arıcıoğlu, M.A., Gedikoğlu, H., Gömleksiz, M., Çiçek, H., Küsmenoğlu, İ. (2016). Ayçiçeğinin Stratejik Ürün Kapsamına Alınmasına İlişkin Araştırma Raporu. Konya Gıda ve Tarım Üniversitesi. 112s. Erişim adresi https://www.bysd.org.tr/uploads/raporlar/aycicegi.pdf

Hisio, T.C. (1993). Plant Atmosphere Interactions, Evapotranspration and Irrigation Scheduling Course I.C.M.A.S. Bari, Italy, 148s.

IPCC, 2013. Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Stocker, T.F., D. Qin, G.-K. Plattner, M. Tignor, S.K. Allen, J. Boschung, A. Nauels, Y. Xia, V. Bex and P.M. Midgley (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, 1535 pp, doi:10.1017/CBO9781107415324.

Kaya, Y. (2016). Ülkemizde Ayçiçeği Durumu ve Gelecekteki Yönü. Tarla Bitkileri Merkez Araştırma Enstitüsü Dergisi, 2016, 25(Özel sayı-2):322-327.

Kaya, Y. (2021). Ayçiçeği Tarımı. T.C. Tarım ve Orman Bakanlığı, Trakya Tarımsal Araştırmalar Enstitüsü Müdürlüğü, Erişim adresi https://arastirma.tarimorman.gov.tr/ttae/Sayfalar/Detay.aspx?SayfaId=54

Özdemir, U., ve Sinan, N.Z. (2020). Çukurova'da Kuru Koşullarda Ayçiçeğinin (Helianthus Annuus L.) Farklı Gelişme Dönemlerinde Uygulanan Yaprak Gübresinin Verim ve Verim Öğeleri Üzerine Etkileri. Ç.Ü Fen ve Mühendislik Bilimleri Dergisi, Cilt: 39-5.

Richards, L.A.; Weaver, L.R. (1944). Moisture retention by some irrigated soils as related to soil moisture tension. Journal of Agricultural Research. 69: 215–235.

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

Süzer, S. (,2008). Ayçiçeği Yetiştiriciliği. T.C. Tarım ve Köyişleri Bakanlığı Tarımsal Araştırmalar Genel Müdürlüğü, Trakya Tarımsal Araştırma Enstitüsü Müdürlüğü. Çiftçi Eğitim Serisi 27.

Süzer, S. (2021). Ayçiçeği Yetiştiriciliği. Erişim adresi http://hayrabolutb.org.tr/media/ziraat/Aycicegi-Tarimi.pdf

Kaya, Y. 2016. The Current Situation and Future Direction of Oil Type Sunflower Production in Turkey. Tarla Bitkileri Merkez Araştırma Enstitüsü Dergisi, 2016, 25 (Özel sayı-2): 322-327

TAGEM, (2020). E-Bülten. Tarımsal Araştırmalar ve Politikalar Genel Müdürlüğü. Sayı 7. 27s

Tamsa, H.K. (2013). Sürekli Solma Noktasının Tayininde Yeni Bir Yaklaşım: Difüzyon-Toprak Nem İlişkisi. Fen Bilimleri Enstitüsü (YL Tezi), Tekirdağ Namık Kemal Üniversitesi.

Tan, Ş. (2007). Ayçiçeği Tarımı. T.C. Tarım ve Köyişleri Bakanlığı Tarımsal Araştırmalar Genel Müdürlüğü Ege Tarımsal Araştırma Enstitüsü Müdürlüğü. Çiftçi broşürü. No.136.

Yıldırım, O. (1996). Bahçe bitkileri sulama tekniği. Ankara Üniversitesi Ziraat Fakültesi. Yayın no 1438. 188s.

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.