CURRENT RESEARCHES in AGRICULTURE, FORESTRY and AQUACULTURE SCIENCES

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DUVAR

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** Siirt Üniversitesi Ziraat Fakültesi Biyosistem Mühendisliği Bölümü

Current Researches in Agriculture, Forestry and Aquaculture Sciences
Editors:

Prof. Atılgan Atılgan Ph.D.
Assoc. Prof. Burak Saltuk Ph.D.

Editor in chief: Berkan Balpetek
Cover and Page Design: Duvar Design
Printing : First Edition-December 2020
Publisher Certificate No: 16122
ISBN: 978-625-7680-04-2

853 Sokak No:13 P.10 Kemeraltı-Konak/Izmir/ Turkey
Phone: 0 232 484 88 68
www.duvaryayinlari.com
duvarkitabevi@gmail.com

Printing and Binding: Sonçağ Yayıncılık Matbaacılık Reklam San.
Ve Tic. Ltd. İstanbul Cad. İstanbullu Çarşısı No:48/48-49
İskitler 06070 Ankara/Turkey
Phone: 03123413667
Certificate No: 47865

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CURRENT SITUATION, PROBLEMS and SOLUTION of PROTECTED CULTIVATION in ANTALYA

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Introduction

Since it is not possible to increase the agricultural areas in proportion to the population increase, it is necessary to obtain higher yields from the existing agricultural lands. High productivity can be achieved by applying new technology and cultural practices properly and effectively (1). The most important of these practices is the cultivation in places that are not suitable for agriculture and without completely depending on external climate conditions.

Therefore, greenhouse technology is a technique to provide favorable environmental conditions for efficient agricultural production. Greenhouse technology is used to protect plants from adverse climatic conditions such as wind, cold, excessive radiation, extreme heat, and pests and diseases (2).

Compared with field-grown crops, a greenhouse produces 5–10 times higher yields per unit area and has 5–10 times higher water-use efficiency (3)

The protected agriculture is classified into ‘greenhouse’ and ‘tunnels’. Greenhouses are permanent structures and cover materials are glass, polyethylene, and polycarbonate. Tunnels are temporary structures using polyethylene as cover material. Protected agriculture is carried out on an area of 5630000 hectares worldwide because it allows farming with less dependence on the climate and it increases income per unit area (4).

Greenhouse vegetable crop production is now a growing reality throughout the world. The degree of sophistication and technology depends on local climatic conditions and the socio-economic environment (5).

Greenhouse cultivation is carried out under different environmental and climatic conditions in the world. Greenhouse cultivation in Northern European countries such as the Netherlands, whose annual average temperature is less than 10 ºC, is generally carried out in glasshouses that have high technology and need a heating system. Most greenhouse cultivation areas in the world are in the countries in the Mediterranean basin. In countries like Turkey that are characterized by a Mediterranean climate with an annual average temperature of 10-20 ºC are typically low-cost in the development of greenhouse agriculture. Plastic-covered greenhouses in such climatic features do not usually needed heating and ventilation systems.

Protected Cultivation in Antalya and Turkey

Turkey's protected cultivation activities began first for research purposes in some state institutions in our southern provinces in 1940. Although the development rate of protected agriculture is very slow between 1940 and 1960, the first commercial production was made in Antalya and İzmir provinces. The developments of protected agriculture in Turkey have occurred after 1970. The main reason for this development has been the use of polyethylene as a cover material in greenhouses (6).

Since the protected agriculture area in Turkey has a greater potential compared to other Mediterranean countries, it has increased by 197% in the last twenty years. Protected agriculture has advantages such as getting more product per unit area, being able to make a living from smaller areas and, enables off-season production, when agricultural activities and plant growth is very difficult. (7). Today, Turkey ranks fourth in the world and second in Europe in terms of protected cultivated areas (8).

The total protected cultivation area in Turkey and Antalya between 2004 and 2019 is given in Figure 1.

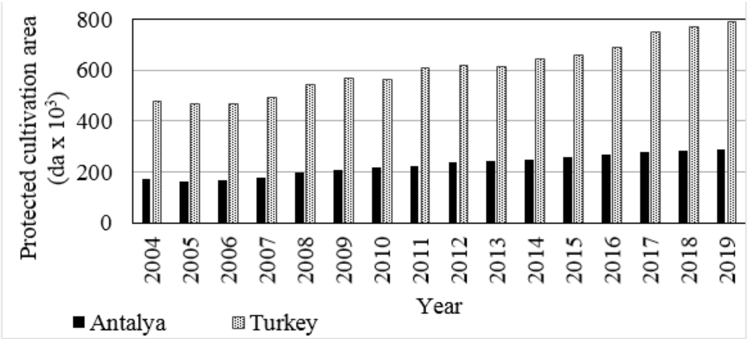

Figure 1 The total protected cultivation area in Turkey and Antalya

Today, the most intensive greenhouse farming activities are performed in Turkey in the Mediterranean region. In Antalya and Turkey, the total area of protected cultivation in the last 10 years has increased by 38.7% and 39.2% respectively. In Antalya, where the Mediterranean climate is dominated, there are a total of 286522 da of protected cultivation area and this area constitutes 36.3% of the total protected cultivation area in Turkey.

Greenhouse Types and Distribution

In Antalya, the low tunnel area has increased by 97.3%, the plastic greenhouse by 52.6%, while the glass greenhouse has decreased by 11.6%, and the high tunnel by 25.3% in the last 10 years.

The distribution of different types of protected agriculture for Antalya and Turkey are shown in Figures 2.

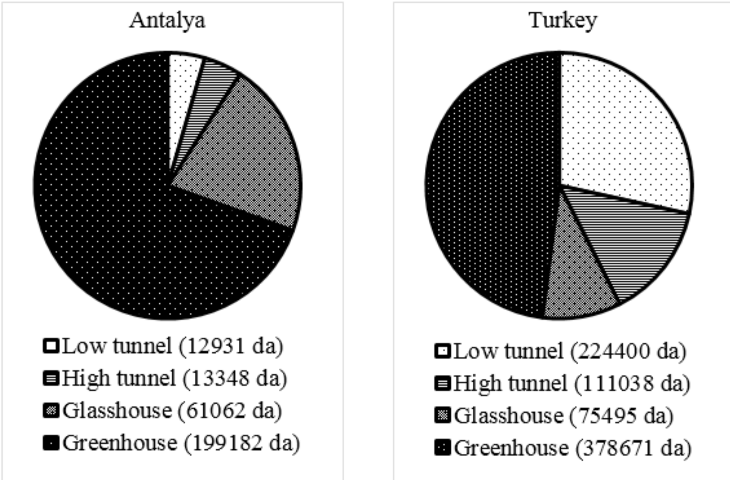

Figure 2. The distribution of different types of protected agriculture for Antalya and Turkey

Of all protected agriculture areas in Turkey, 28.42% are low tunnels, 14.06% high tunnels, 9.56% glasshouse, and 47.95% plastic greenhouse. Antalya occupies 4.51%, 4.65%, 21.31%, and 69.51% of these percentage values, respectively. Low and high tunnels in Antalya are less preferred compared to other greenhouse types. Therefore, 5.8% of Turkey's low tunnel areas are located in Antalya.

The distribution of protected cultivation areas in the districts of Antalya is given in Figure 3

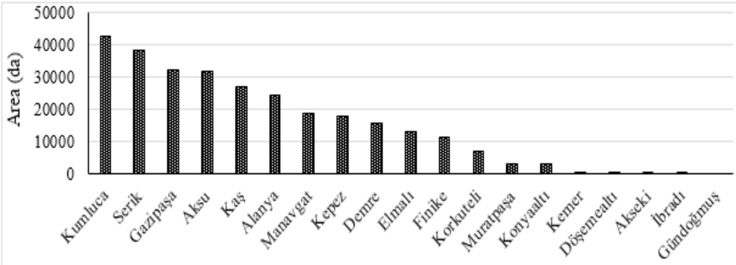

Figure 3. The distribution of protected cultivation areas in the districts of Antalya

Due to the climatic characteristics and locations, protected cultivation areas in Antalya are concentrated mostly in Kumluca (42502 da), Serik (38225 da), and Gazipaşa (32280 da). 85% of protected agriculture areas in Kumluca district consist of plastic greenhouses.

The data of Antalya low tunnel areas are given in Figure 4.

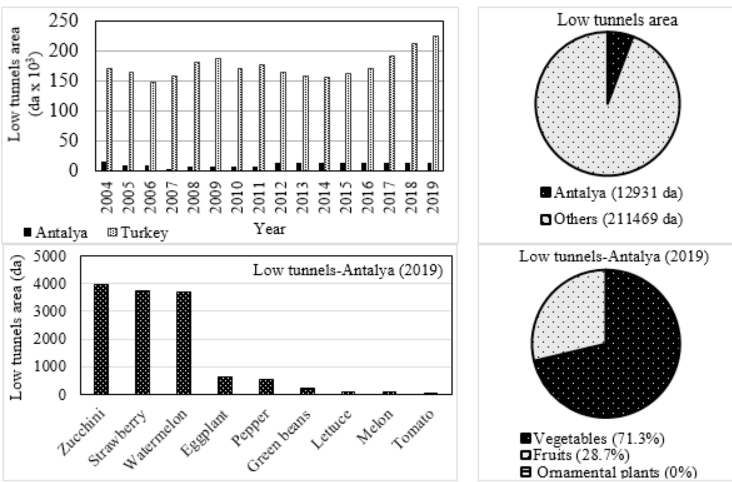

Figure 4. The data of Antalya low tunnel areas

Low tunnels are most common in Egypt, France, Italy, and Turkey. As of 2019, while low tunnel cultivation was carried out in an area of 12931 da in Antalya, it was 224400 da in Turkey. While the low tunnel area in Turkey has increased in the last five years, a similar increase has not occurred in Antalya. Only 4.51% of the low tunnel areas are located in Antalya. The low tunnel areas consist of 71.3% vegetables and 28.7% fruits, while no ornamental crop production is cultivated. In terms of the growing area, in the low tunnels in Antalya, zucchini (3955 da) and watermelon (3675 da) from vegetables and strawberries (3719 da) from fruits are grown.

The products obtained from the low tunnel in Antalya and the data of these products are given in Figure 5.

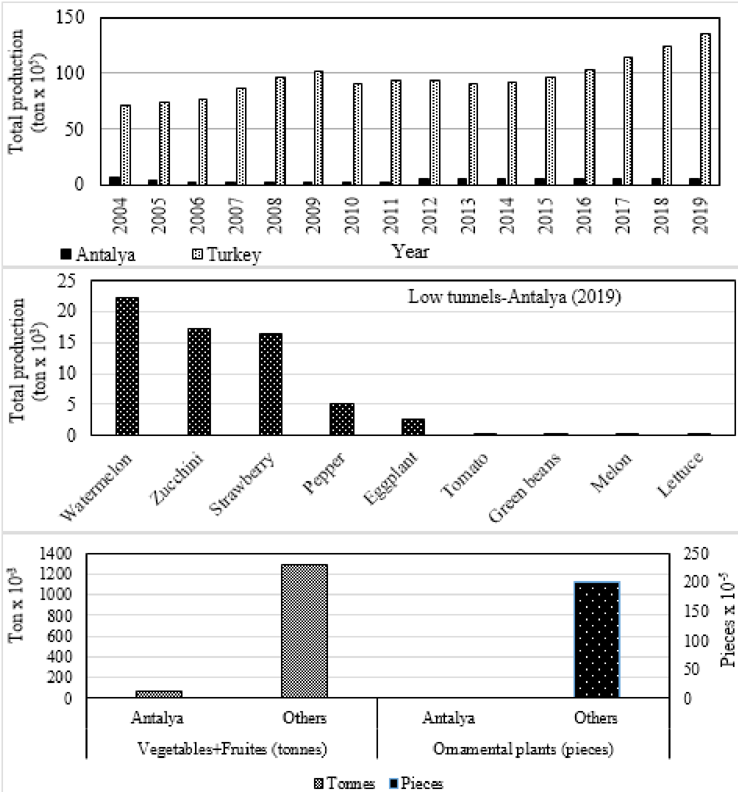

Figure 5. The products obtained from the low tunnel in Antalya and the data of these products

The total amount of product obtained from the low tunnels in Turkey has increased in parallel with production areas. The total amount of production constitutes 74.8% for vegetables and, 25.2% for fruits from the low tunnels in Antalya. Although watermelon is in third place in terms of production area, it is first in terms of production amount. In 2019, as much as 22225 tons of watermelon was harvested in the low tunnels in Antalya. In terms of production amount, only 4.82% of the total fruit and vegetable production (65000 tons) in Turkey is obtained from Antalya's low tunnel areas.

The data of Antalya high tunnel areas are given in Figure 6.

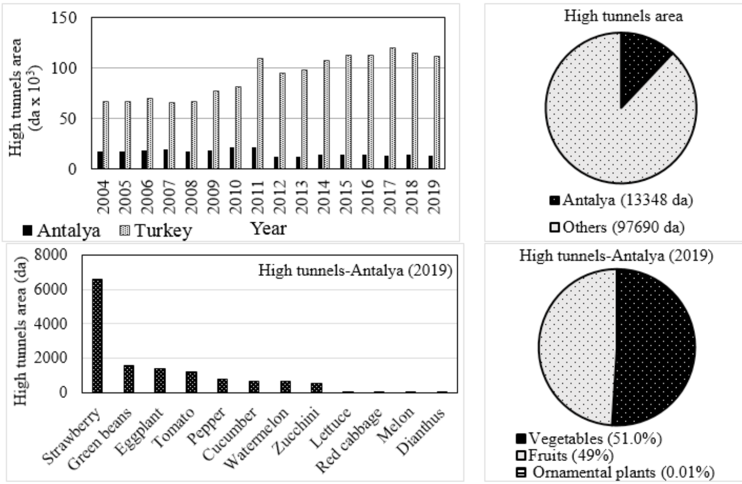

Figure 6. The data of Antalya high tunnel areas

High tunnel area in Turkey increased between the years 2012-2017, although it has decreased in the last two years. In 2019, the total low tunnel cultivation area in Turkey was 111038 da, while 13348 da of this low tunnel cultivation land was in Antalya. In Antalya, the total high tunnel cultivation area accounts for 12% of the whole of Turkey. While strawberries are grown in 49% of this area, ten different types of vegetables are grown in 51%. Also, dianthus is grown in a very small area (4 da).

The products obtained from the high tunnel in Antalya and the data of these products are given in Figure 7.

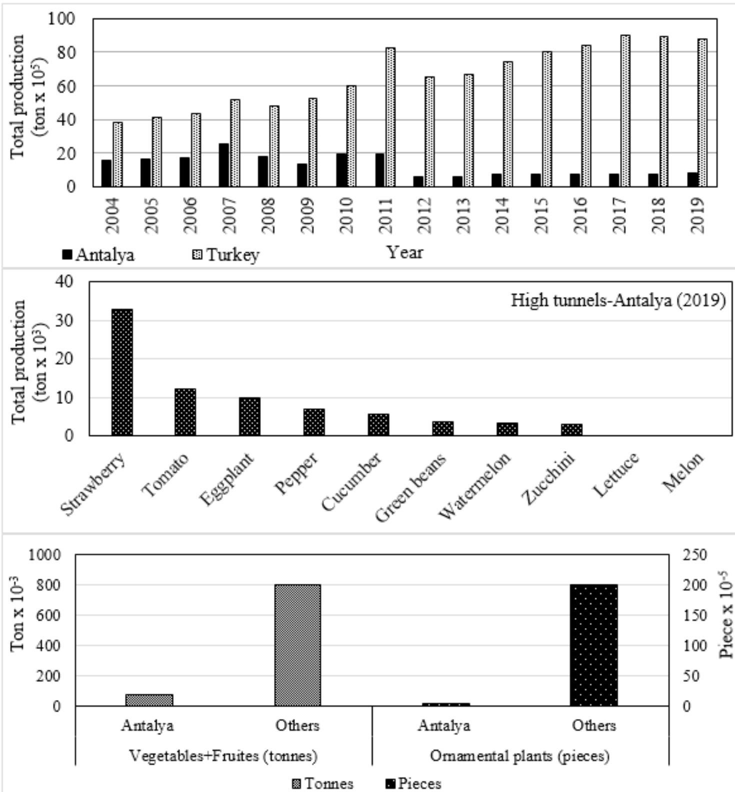

Figure 7. The products obtained from the high tunnel in Antalya and the data of these products

Due to the decrease in high tunnels area in the last three years, the total vegetable and fruit production has decreased. Strawberries constitute 41.9% (32780 da) of the amount of the product obtained from the high tunnel due to the growing area of strawberries in the high tunnels. Tomato follows the strawberry with 15.8% (12380 da) production amount.

The data of Antalya glasshouse areas are given in Figure 8.

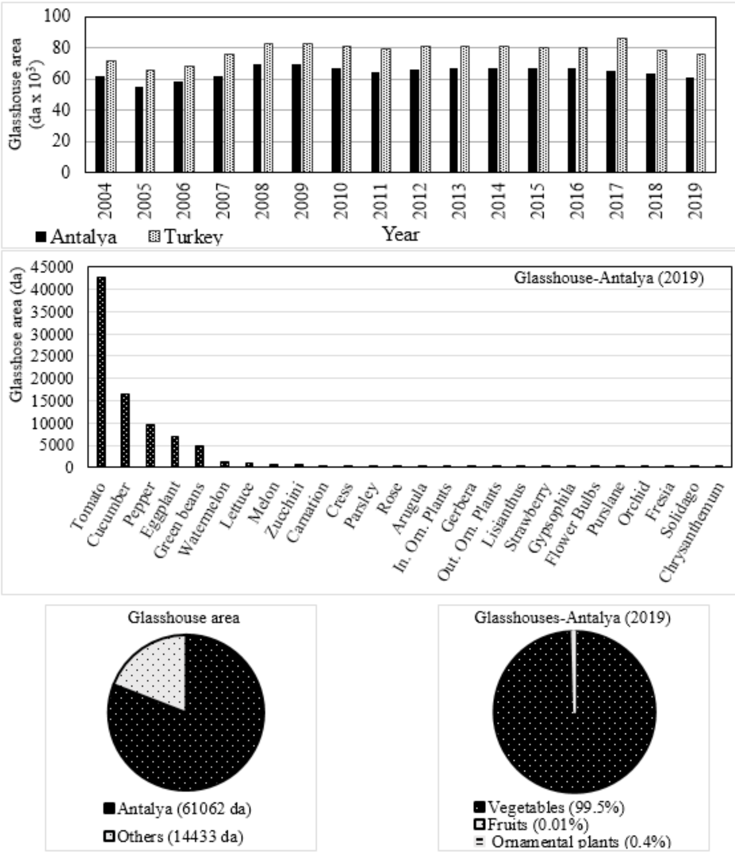

Figure 8. The data of Antalya glasshouse areas

The glasshouse area in Turkey increased between 2005-2008, remained nearly the same between 2008-2017, and decreased between 2017-2019. Although the variation in the glasshouse area over the years in Antalya province is similar to Turkey, the decrease in the glasshouse area started in 2016. Glasshouse establishment has decreased since the initial investment cost is higher than the plastic greenhouse. In terms of initial investment cost, there is nearly two times the price difference between glasshouses and plastic greenhouse. Therefore, plastic greenhouses are preferred instead of glasshouses that have completed their useful life. Antalya glasshouse area corresponds to 80.9% of the glasshouse area in Turkey. 26 different products are grown in glasshouses in Antalya. 13 of these products are vegetables, 12 pieces are cut flowers and ornamental plants, and 1 piece is fruit. Vegetables are grown in almost all glasshouses in Antalya, which corresponds to 90% of the total glasshouse areas. When the distribution percentages of the products grown in glasshouses are examined in terms of production area, tomatoes are grown in 50.5% of the glasshouses in Antalya. The second and third crops with the highest production area in the glasshouse are cucumber (19.5%) and pepper (11.3%), respectively.

The products obtained from the glasshouse in Antalya and the data of these products are given in Figure 9.

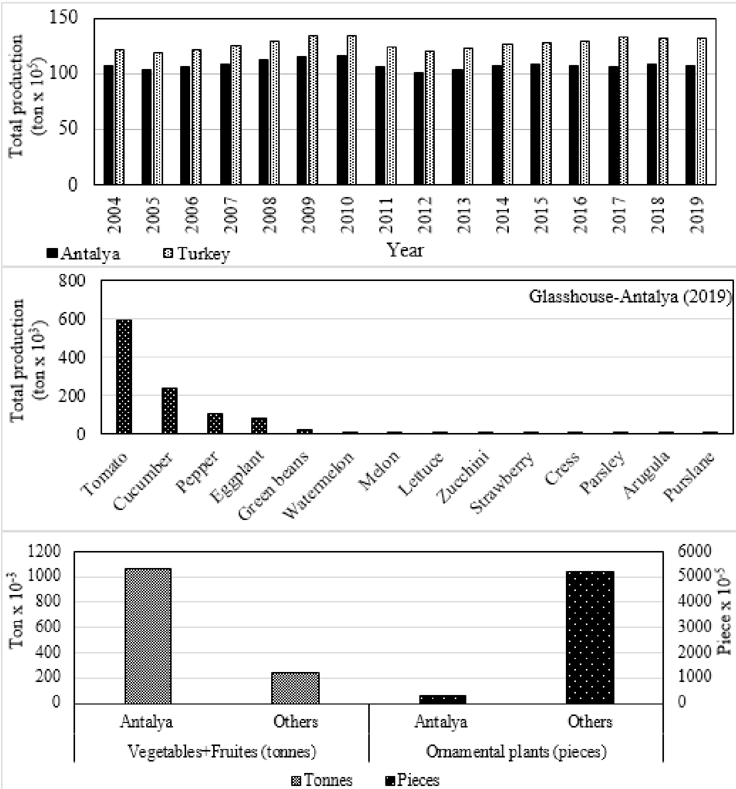

Figure 9. The products obtained from the glasshouse in Antalya and the data of these products

The total amount of products provided to the market through the glasshouse in Antalya is 80% of the total amount of product obtained from glasshouse in Turkey. As of 2019, most products from the glasshouses in Antalya were obtained from tomatoes (591326 tons), cucumber (241046 tons), and peppers (108556 tons), which correspond to 55.4%, 22.6%, and 10.2% of the total production, respectively. Although cut flower and ornamental plant potential are low in terms of production area, 5% of the cut flower and ornamental plants obtained from glasshouses in Turkey are grown in glasshouses in Antalya.

The data of Antalya greenhouse areas are given in Figure 10.

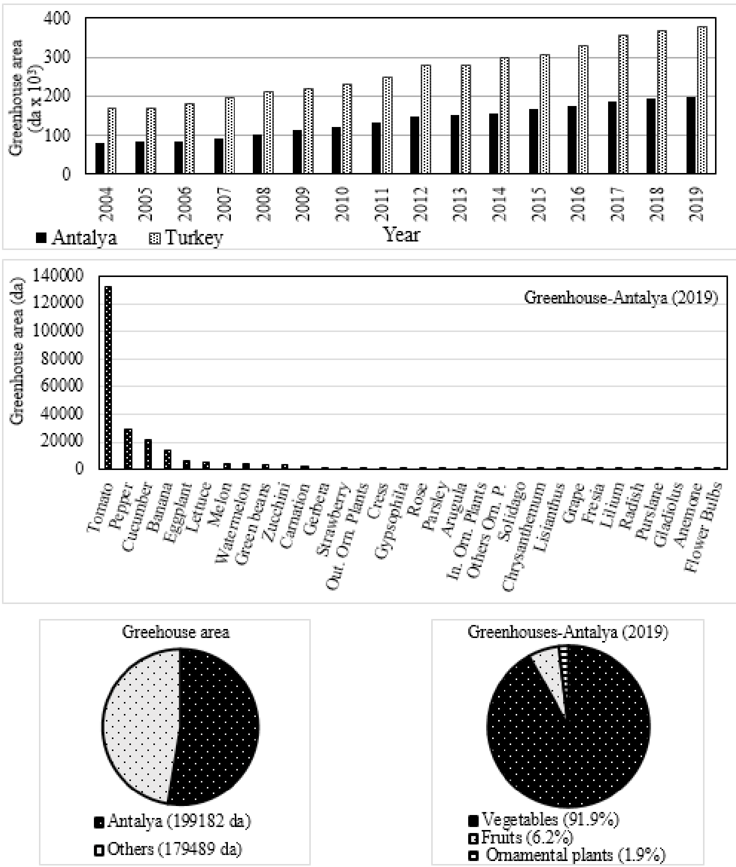

Figure 10. The data of Antalya greenhouse areas

Compared to other types of greenhouses, interest in plastic greenhouses is increasing every year in both Antalya and Turkey. Turkey and Antalya plastic greenhouse areas in the last 10 years have increased by 71.9% and 76.1%, respectively. 52.6%

of the plastic greenhouse areas in Turkey are located in Antalya. Thirty-two different plant varieties are cultivated economically in plastic greenhouses in Antalya. This number is forty-nine in overall Turkey. As of 2019, most products from the plastic greenhouses in Antalya were obtained from tomatoes (132594 da), pepper (29437 da), cucumber (21630 da), and eggplant (6608 da), which correspond to 62.7%, 13.9%, 10.2%, and 3.1% of the total areas, respectively. The plastic greenhouse vegetable cultivation area where vegetables are cultivated in Antalya corresponds to 24% of the protected cultivation areas in Turkey, 48.9% of the greenhouse areas in other Turkey's provinces. In 2019, the greenhouse areas in Antalya consist of 91.9% vegetables, 6.2% fruits, and 1.9% cut flower and ornamental plants. Solanaceous fruits (tomato, pepper, and eggplant) and cucurbits (melon, zucchini, watermelon) crops account for more than 80% of the protected area. The reasons for the diffusion of these crops are the large market demand, the adaptability to variable climatic conditions of unheated shelters and to long-distance transportation, and the extended cycle that enhances the exploitation of the greenhouse (9).

Banana cultivation in plastic greenhouses in Antalya has increased by 57.5% in the last 10 years. A significant increase in banana greenhouse areas is expected after 2020. As of 2020, many new banana greenhouses have been built and many greenhouses used in soilless agriculture are turned into banana greenhouses.

The products obtained from the glasshouse in Antalya and the data of these products are given in Figure 11.

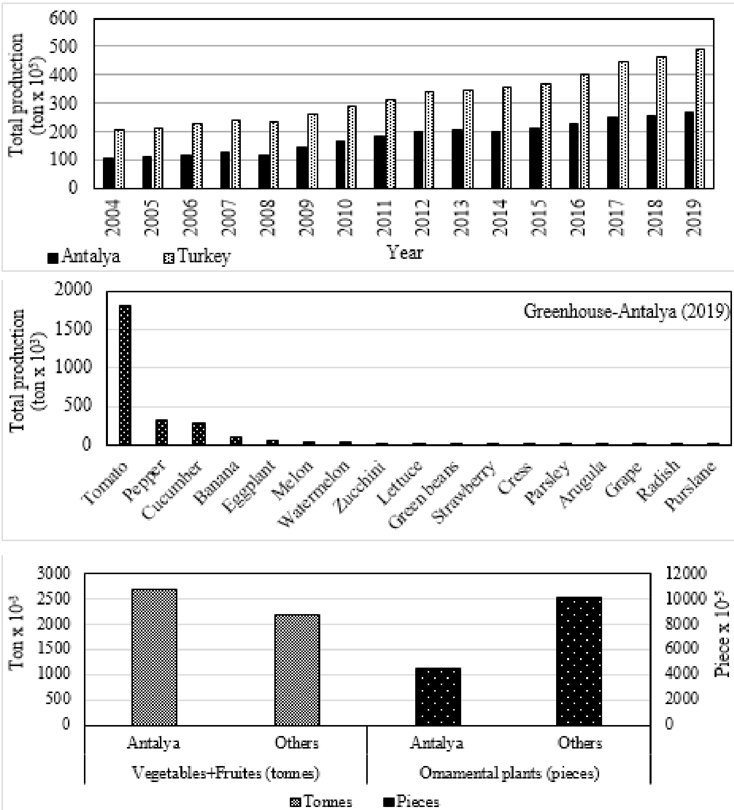

Figure 11. The products obtained from the greenhouse in Antalya and the data of these products

The total yield in plastic greenhouses in Antalya is increasing every year. Total production in plastic greenhouses has increased by 62.5% in the last ten years. In 2019, 33.3% of the vegetables produced in protected agriculture in Turkey are cultivated in plastic greenhouses in Antalya. As of 2019, most products from the glass greenhouses in Antalya were obtained from tomatoes (1817166 tons), pepper 319317 tons), cucumber (281677 tons), and banana (68995 tons), which correspond to 67.2%, 11.8%, 10.4%, and 2.5% of the total production, respectively. The total amount of tomatoes produced in plastic greenhouses in Antalya corresponds to 44.5% of the total tomato amount produced in protected agriculture in Turkey. The total amount of vegetables and fruits produced in plastic greenhouses in Antalya is more than the total produced from plastic greenhouses in all other cities. For these reasons, greenhouse cultivation in the Antalya region is a very important city in terms of both economy and food supply. Although the plastic greenhouse area used for the production of cut flower and ornamental plants in Antalya is less than other vegetable and fruit growing areas, it corresponds to 36.7% of the total amount of cut flower and ornamental produced in protected agriculture in Turkey.

The Effect of Climate on Protected Cultivation in Antalya

Antalya has a typical Mediterranean climate with rainy winters and hot and dry summers. Mean long-term annual climatic values for the Antalya region are given in Table 1.

Table 1. Long term annual mean climatic values of Antalya (10)

Months	Mean. Temperature (°C)	Min. Temperature (°C)	Max. Temperature (°C)	Wind Speed (m sn^{-1})	Relative Humidity (%)	Sunshine Hour (hour day^{-1})	Solar Intensity (kWh m^{-2} day^{-1})
January	10.0	5.9	14.9	3.5	65.5	5.0	2.71
February	10.6	6.4	15.5	3.6	65.3	5.7	3.53
March	12.8	8.0	17.9	3.3	66.2	6.7	4.98
April	16.3	11.2	21.3	3.0	67.6	7.9	5.93
May	20.5	15.2	25.5	2.6	66.6	9.6	7.09
June	25.3	19.6	30.7	2.9	59.3	11.3	7.78
July	28.4	22.7	34	2.8	57.1	11.5	7.52
August	28.3	22.7	34	2.7	59.3	11.2	6.67
September	25.1	19.4	31.1	2.8	59.1	9.7	5.50
October	20.5	15.2	26.5	2.8	60.6	7.8	4.12
November	15.4	10.7	21.2	2.9	64.6	6.3	3.03
December	11.6	7.6	16.6	3.3	67.0	4.8	2.32
Mean	18.7	13.7	24.1	3.0	63.2	8.1	5.1

In agricultural cultivation, during the period from seedling planting to harvest, temperature, humidity, wind, and light significantly affect the yield and quality of the product.

Protected agriculture is an enclosed environment that generates its own microclimate. This enables farmers to manipulate inputs and outputs by controlling parameters such as heating, cooling, temperature, humidity, CO_2 enrichment, and fertigation (applying liquid fertilizer via irrigation). As protected agriculture allows the control and manipulation of microclimate, thereby creating a conducive environment for plant health and growth, it could deliver economic, environmental, and social benefits. (3) Temperature affects many biochemical and physiological functions, including photosynthesis, transpiration, and enzymatic activities. High temperature induces stomata activator, thus affecting plant growth, photosynthesis, transpiration, and drying tolerance. Low temperatures disrupt the absorption of radiation by inhibiting the Calvin-Benson photosynthesis cycle. In case the temperature drops below 15 ° C, the development of the plant slows down, the ripening of the fruit is delayed and the yield decreases significantly (11).

The minimum, maximum, and optimum temperature requirements of some vegetables commonly grown in protected agriculture in Antalya are given in Table 1.

Crop	**Minimum Temperature**	**Optimum temperature**	**Maximum temperature**
Tomato	10	23-27	32
Cucumber	18	25-30	34
Eggplant	12	25-28	34
Peppers	18	22-30	34
Lettuce	7	15.5-18.3	24
Strawberry	0	17-25	29
Beans	0	16-22	30
Peas	1	15-20	32.2
Banana	10	21-22	39
Watermelon	18	25-30	34

Low-tech greenhouses are not heated regularly, as the average daily temperature does not fall below 7 °C on the Mediterranean coastline. As in the Mediterranean coastal countries, in Antalya, there is no heating application based on providing the optimum temperature in protected agriculture. Usually, greenhouses are heated in order to protect the plants against frost using simple methods if the temperature is too low.

Depending on the size and location of the greenhouse ventilation openings, the wind speed inside the greenhouse varies between 0 and 1.3 m s^{-1}. Since wind speed is an important climatic parameter affecting heat and mass transfer in greenhouses, it is evaluated together with other climatic parameters.

Vapour pressure deficit (VPD) is the driving force for transpiration in plants and it changes exponentially with the change in the ambient temperature. High VPD increases stomatal resistance and transpiration while low VPD causes dehydration, transpiration, and necrosis. Extreme humidity affects both plant vegetative growth and fruit quality and increases the likelihood of disease (3)

The optimum relative humidity requirements of some vegetables commonly grown in protected agriculture in Antalya are given in Table 2.

Crops	**Relative Humidity**
Tomato	50-60%
Cucumber	80-90%
Eggplant	65-75%
Peppers	60-65%
Lettuce	65-80%
Strawberry	50-60%
Beans	70-80%
Peas	70-80%
Banana	95-100%

Since most of the greenhouses in the Antalya region do not have a ventilation system, the humidity inside the greenhouse is adjusted by opening and closing the ventilation windows (7). In greenhouses without a ventilation system, the relative humidity inside the greenhouse is higher in the fall season compared to outside the greenhouse, while it is higher outside the greenhouse in the spring season. This situation is due to the increase in the relative humidity in the greenhouse as a result of closing the ventilation windows due to the low air temperatures in the fall period. In addition, relative humidity increases as the temperature suddenly decrease after sunset (7). Leaf pruning is widely applied by growers in order to protect against fungal diseases caused by high humidity (12).

Solar energy is vital for plant metabolism, growth, and development (3) Total radiation in November, December, and January should be 2.3 kWh $m^{-2}day^{-1}$ for effective plant cultivation in protected agriculture. In order to show the heating and cooling need of the greenhouses in Antalya, Emekli et al. (2008) (6) presented Figure 2 by making use of the distribution of the long annual average daily temperature and total radiation values throughout the year.

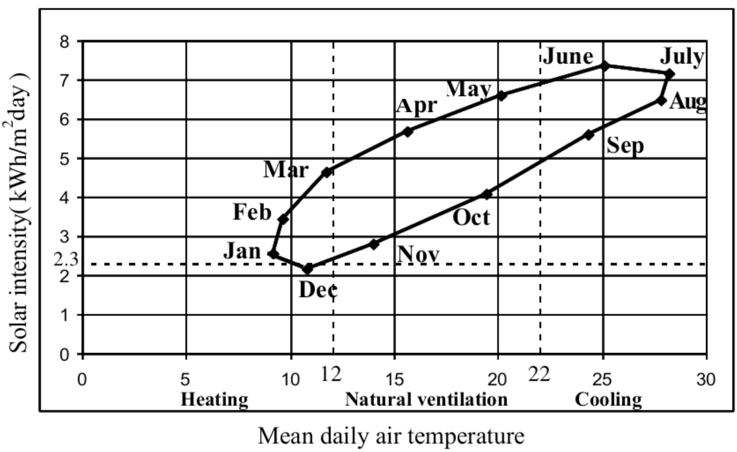

Figure 2. The distribution of Antalya daily temperature and total radiation values throughout the year and periods in which greenhouses need heating and cooling (6)

As can be understood from Figure 2, for efficient protected agriculture in Antalya, greenhouses need heating from mid-December to early March, while cooling needs from the end of June to the end of September. Emekli et al. (2008) (6) stated that the critical limit value of the total daily radiation is 2.3 kWh m^{-2} day^{-1} and stated that this value was close in December and therefore both artificial lighting and heating were required in order to fulfill the crop production in the mentioned month under optimum conditions.

High temperatures occurring at specific times of the year, rising relative humidity at night, and low light intensity in winter are the main problems regarding the climate that limit the farmers engaged in protected agriculture in Antalya.

Problems and Solution of Protected Cultivation in Antalya

The protected cultivation area in Antalya corresponds to 36.3% of Turkey. While protected agriculture was carried out on an area of 286522 da in Antalya in 2019, it was carried out in an area of 789604 da in Turkey.

Only 3% of the greenhouse in Turkey are modern, high-tech greenhouses (13). In Antalya, the use of modern greenhouses is much smaller than in Turkey. The average greenhouse area in Antalya is 4 da (14). Average greenhouse size is far from being economic in scale and this creates several problems about production and marketing, e.g., the small scale greenhouses hinder the use of modern production technologies (15)

Low technology Mediterranean type greenhouses do not have ventilation and heating systems (7). In Turkey, greenhouse production is carried out by taking advantage of the favorable climate while keeping the operational cost at a minimum level. Thus, the majority of the greenhouses are heated for frost prevention except for indoor plant production greenhouses (16). 90% of the greenhouses with the heating system are inefficiently and incorrectly heated (17). Greenhouse heating systems tend to be designed to protect the crops from frost rather than to maintain adequate temperature for growing. As a consequence, potential crop yields are not being obtained (15).

According to the past Wholesale Market Law No. 552, growers had to deliver their products to brokers in wholesale centers. However, the new legal regulation in 2010 has removed this obligation. Although this obligation is corrected by legal regulation, unfortunately, producers are dependent on wholesale markets because protected agriculture is made as a small family business and our producers are unorganized. This marketing structure generally acts against the growers' interest with the growers' share of final consumer price being as low as 10% for some crops (15).

Yilmaz et al. (2005) (15) reported the excessive use of pesticides and fertilizers in greenhouse cultivation in Antalya province. Moreover, the growers do not have enough information about the health effects and safe use of chemicals and pesticides (18). Although many precautions are taken in this regard and the producers are given continuous training by different institutions, the producers carry out these plant protection practices with their daily clothes and do not use personal protective equipment.

Growers also use excess fertilizer in greenhouse production, resulting in salinity problems in soils and nitrate pollution of the aquifers. A study conducted in the Antalya province showed that salinity problems exist in greenhouse soils and that 50% of wells contain nitrates exceeding permitted levels (15).

In order to get more efficiency from greenhouses per unit area in Antalya, it is necessary to modernize low-tech greenhouses and turn them into medium-high technology greenhouses. In these greenhouses to be modernized, heating and ventilation systems should be used to ensure continuous vegetative production throughout the year. By means of land consolidation, operating costs can be reduced and more economical production can be made by combining greenhouses belonging to the same enterprise. Agricultural innovations in the country and in the world should be followed and new information should be transferred to the growers. Therefore, the number of existing agricultural consultants should be increased. Training on the use of fertilizers and pesticides given to producers should continue, and the use of fertilizers and pesticides should be strictly controlled.

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●*Chapter-2*●

WATER RESOURCE and IRRIGATION in SOMALIA: A REVIEW*

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Introduction

Somalia is a semi-peninsula country, which is located in the northeastern (horn) part of Africa. It is bordered by Ethiopia to the west, Kenya to the south, and Djibouti to the north. It is also bordered by the Gulf of Adan and Red-sea to the northeast and the Indian Ocean to the east. The total land area of the country is estimated about 637,600 km^2, of which 45% is rangeland suitable for livestock grazing, 30% is classified as desert land, 14% is covered by wooden forest, and 11% remaining land is arable (1). Geographically, Somali stretches about 1550 km from north to south with the latitude of 12 °N and 1°S and for almost 1095 km from west to east with the longitude of 41° E and 51°E. The south and central of the country has a low-lying landscape with uniform flat except some hills and sand dunes alongside the coastal area. In contrast, the northern Somalia is dominated by mountain plateau. Due to light rainfall, much of the country's land area is suitable for nomadic herding with about 60% of its population involve in pastoralism and farming. Pastoralism and livestock herding are the two mainstays of people's livelihood and security, in terms of daily sustenance and the key source of exporting earnings. As livestock contributes 40% of GDP and more than 50% of export earnings, agriculture becomes the second major employment activity and economic sector in the country (2).

The country's agricultural production largely depends on rainfall. Most farmers practice rain-fed agriculture except farmers living on the riverine of the perennial streams (Juba and Shebelle rivers) in southern regions. The dependency on rain-fed agriculture by the majority of the farmers and pasture had caused the economic extremely vulnerable to vagaries of weather. In Somalia, the rainfall is normally, low and erratic. The annual average rainfall of the country is about 250 mm. The northern plains are hot and dry with annual mean rainfall less than 250 mm. The rainfall is high in the south and south-west regions with approximately 400 mm and 700 mm (3). The rainfall received in the central part of the country, which is characterized by a semi-arid climate, is about 50-150 mm. A small area along the coastal land of Somalia is classified as sub-humid climate (2).

Somali is characterized by arid and semi-arid climates. Rainfall is the only feature, which defines the climate and has spatial and temporal variability. The country's climate is determined by the movement of the Intertropical Convergence Zone (ITCZ). The movement of this zone results in two rainy seasons, i.e. the Gu (spring) season, which starts last days of March and ends in the first days of June, as the ITCZ passes northwards, and the Deyr (autumn) season which starts from the last days of September and ends in the first days of December, as the zone passes to southward. Rainfall is considered the only meteorological parameter, which affects the life in Somalia (4).

Historically, Juba and Shabelle rivers are the country's irrigation source for the southern part, particularly for small-scale farmers in the riverine of both streams. The development and management of irrigation began in 1920, with implementations of the Jowhar Sugar Estate and construction of the irrigation barrages along Shabelle and Juba river basins, which encouraged a new crop production system on commercial farming for export (5). Boreholes and shallow wells are also groundwater sources, which if they are developed can provide an ample amount of irrigation water to both small-scale and commercial farming particularly for those not bordered by the rivers. Precipitation also contributes to a significant amount of water for agricultural production.

The objective of this review is to summarize the past studies and literatures about surface and groundwater resources as well as irrigation in Somalia and shed light on the gaps for the future researchers who will be studying in Somalia.

Water Resource in Somalia

Juba and Shabelle Rivers

Rivers are the main source of surface and fresh-water, which plays a crucial role in the economic development of the society in sustaining life-supporting ecosystem service and productive environment. As the new local and national source of water resources becomes scarce, limited, and difficult to utilize, water resource and management is increasingly becoming critical. Many countries located in the regions characterized by arid and semi-arid climate are facing water crises, which will be increasingly forced to regard the possibilities of exploiting the water that available in international river basins. Hence, the issues relating to international water use are gradually becoming more important and complex. Because the available and easily exploitable surface and fresh waters are in the river basins, which are shared by two or more riparian countries. River shared by countries located in such dry climate regions is expected to become a source of conflict among the sharing countries (6). Somalia and some of its neighbor countries in the horn of Africa are among the countries where water is scarce and permanent available surface water exists in rivers. Juba and Shabelle are two permanent streams, which are shared by Ethiopia, Kenya and Somalia. The primary economy of Somalia depends on agriculture and livestock and it is necessary to increase water use for food production. Somalia and other riparian countries had never negotiated about the sharing of this scarce water resource exist in rivers and the region is ravaged by war (7).

Shebelle River: Shabelle River (Figure 1) originates in the high lands of Baile Mountains in Ethiopia at an altitude of 4230 m above the sea level and the drainage area it covers is estimated with 297000 km^2, 63.5% of this area lies in Ethiopia, which corresponds to two-thirds of the river (8, 9). Within Ethiopia, there are several tributaries that contribute the river's runoff. Shabelle River flows to the southeasterly direction; it passes through the dry lands province of Ethiopia and crosses wide valleys in southern Somalia. The river runs a distance of 2526 km, of which 1290 in Ethiopia, it does not normally flow into the Indian Ocean except when there are heavy rainfalls but it ends in an off-stream area, where it is finally lost in the sand in southern Somalia, feeding an ecological area and contributing a significant area of groundwater aquifers.

The average runoff contributions of the river are 3387 M m^3 and 2384 M m^3 at Gode town in Ethiopia and Belet-Weyne town in Somalia, this amount of runoff water result in rainfalls in both high lands of Ethiopia and Somalia (6).

However, the basin is impacted by the climatic conditions existing in the regions including droughts and floods. When there is low rainfall, the level of the river flow decreases and these low river streams impact both small-scale and commercial farmers and livestock keepers as well. When there are heavy rainfalls in the high lands of Ethiopia, there is a high risk of flooding to downstream communities.

Juba River: Jubba River (Figure 1) also originates in Ethiopia, where its large tributaries (Genele, Dawa and Weyb) meet near the border of Somalia. Unlike Shabelle River, Juba River is shared by Ethiopia, Kenya, and Somalia. Its drainage basin area is about 452000 km^2 (8). Shabelle and other Dare catchments are also part of Juba before reaching the Somali and end to the Indian Ocean in Southern Somalia. Excluding Shebelle and Lag Dare catchments, the total area of the Juba basin is 221000 km^2 at the mouth of the river near to Kismayo based on delineation in Shuttle Radar Topography Mission (SRTM) 30 m from USGS. 30% of the river basin lies in Somalia, 65% lies in Ethiopia and 5% in Kenya, (10).

Figure 1. Map showing the Juba and Shebelle river basins (7).

The annual rainfall, which can contribute to the river flow, is 1600 mm and decreases by reaching 200 mm in southward near the border. The average rainfall that contributes to the basin is 500 mm and the annual mean run-off of the river in Ethiopia is 6600 M m^3, 6200 M m^3 in Somalia while Kenya's contribution to the runoff of the river is very low and considered insignificant (6). Juba River conveys a considerable volume of sediments; the two river basins are one basin with three sub-basins, Shabelle, Juba and Laag-dheera. These three sub-basins occupy a total area of 749000 km^2 (8). The total drainage area of the two basins previously estimated at 805100 km^2 (11). Due to high evapotranspiration and low rainfall, the river makes a small amount of runoff. Although the most surface water resources in Somalia are in the rivers, its water runoff contribution is minimal and considered as insignificant. Juba River is smaller than Shabelle River but has higher annual runoff than Shabelle River (10). Like the Shabelle River, Juba River associates groundwater aquifers in the region and a source of agriculture and livestock production.

Water collection structures and dams in Somalia

Most of the development projects of both rivers had begun post-independence; the Somalia government had engaged several agricultural development projects by exploiting the two rivers. Before the collapse of Somalia estate in 1991, 10 barrages and 1 dam were built to regulate irrigation activities with irrigation canals and 161583 ha of land were covered under irrigation control. Most of the irrigation operation only existed in agricultural land surrounding the riverbanks. In the 1987/1988 farming seasons, the irrigated lands were 112950 ha. There were no dams built on Shabelle river, there was a big depression built near Jowhar, which can carry about 200 M m^3 of water (6). The depression or off-stream was aimed for flood protection when the river's flow level is high and to utilize in dry seasons when the river is low and there is no expected rainfall.

The irrigation projects in the Juba River were included Juba Sugar Project (JSP), the Mungaab rice irrigation project and the Arar banana irrigation project. Fanole project was the only dam built in the country for irrigation development, hydropower production and flood reduction. After the collapse of the civil war, Fanole dam on Juba River, off-stream near Shabelle River and important canals those were used for irrigation of remote agricultural lands were destroyed, some of the canals were rehabilitated by local farmers but not enough to carry ample of water to reach the targeted land (10).

Groundwater, boreholes, aquifers and wells in Somalia

Groundwater is considered as the second freshwater reservoir exists on the earth. It contains more than 100 times another surface freshwater including river streams and lakes. Groundwater plays a crucial role in the hydrological cycle, plant growth, and formation of soils from their origin rocks and provides necessary water for human activities (12). In Somalia, groundwater results in infiltration of rainfall and surface water such as rivers and temporary streams locally known as 'toggs'. Therefore, in southern Somalia, where the two perennial rivers traversed have the best hydrological condition, other areas like the central rangelands are characterized by less groundwater recharge, because the groundwater recharge depends on rainfall, while the infiltration of the rainfall is estimated at 5% due to erratic low rainfall which ranges from 100-250 mm respectively.

According to Basnayat (13), the main transboundary hydrological aquifers in southern Somalia extends towards the north in Ethiopia and west in Kenya are Basement Complex, Xudur, and Bardere aquifer, Coastal aquifer in coastal land of southern Somalia, and upper and middle Shabelle Valley.

In Buur Area has a well-defined aquifer known as Basement Complex aquifer, due to groundwater movement characteristics, it influences the Xudur-Bardere aquifer. Marble, granites, quartzite are found rocks in the Basement complex. Recharge usually occurs with the rainfall and runoff alongside the toggas. Insignificant recharge happens in areas characterized by alluvial black clays, sub-surface water found in such this clay is salty. Some groundwater bodies are an insignificant and sometimes a small amount of water can be found in a rock.

Xudur-Bardere aquifer occurs along Baydhabo cliff via the joints of stratification and Karsitic area through dolines, sinkholes where there is rapid infiltration of rainfall and runoff (14).

Groundwater is abundant, where is dominated by Baydhabo Jurrasic Limestone but is almost zero where residual clay covered due to impermeability. The flow of underground water starts from Baydhabo plateau extends towards northeast and northwest. The groundwater of Upper Juba valley flows from east to west and from north to south. There are limestone formations. There are also two discharge areas in Gedo region. The first one is located in the western side of Jubba Valley, where the groundwater flow through many small springs along the riverbed of the toggas and the second discharge zone was found near Garbahaarey (13).

Coastal Aquifer: This aquifer spreads from the lower reaches of Juba, Shabelle, Lag Dera and Lag Badhana Basins to south coastal zones. This groundwater results in direct rainfalls from Juba and Shabelle basins, the underground water flow from Kenya, runoff and underground from basement complex (13).

Upper and Middle Shabelle Valley: This valley is a broad valley surrounded by geological formation composition mainly limestone, gypsum, marls and sandstones. The Middle Shabelle Valley builds up with clay and sandy clay layers. The groundwater flow around the riparian zones of the river occurs mainly along the Shabelle River (13).

Dug-shallow wells and boreholes are also sub-surface water resources, which significantly supply water demand of communities living away from the rivers. Dug wells run-dry due to prolonged droughts. According to FAO-SWALIM, the water of these wells are poor in quality due to organic contaminations and common outlets for both human and livestock. About 770 shallow-wells exist in Bakool region; most of these wells are not functional as they were broken down (15). The mean depths of shallow wells are estimated with 12 m and some of the wells are lined with concrete, while most of the wells are lined with traditional timber logs. In Elberde there are only 10 shallow-wells (13).

In Bay region, there are 610 shallow wells, of which 250 are in Baidoa, 50 in Kansahdere, 60 in Berdare, 90 in Burhakabe and 160 in Dinsor. In the region, every household has their own well particularly in the rural community. The average well depth is different and it ranges of 10-8. In the Hiraan region there are 200 shallow-wells both communal and private-owned. In Gedo, there 40 shallow-wells that are used by both nomadic and permanent households (13).

Most of the wells were poorly constructed by using traditional timber logs. They are not well lined and sometimes the run-offs seep back into the wells. This runoff seepage could result in organic contaminations and deteriorate the quality of the water even used by the human.

Unlike shallow-wells, boreholes provide water throughout the year and are not mostly affected by prolonged droughts. During the period of droughts, majority of community living away the rivers use boreholes as the water sources. According to UNICEF, boreholes along the shallow-wells are the water source existing in the Bakool region. The total boreholes in Bakool region are 31, of which only 10% are functioning. Two of the functioning boreholes are in Teyeglow and one is in Wajid. The mean depth of Teyeglow boreholes are 90 m. Due the civil wars, most of the boreholes were filled with stones and are not functional.

In Bay region, there are 144 of boreholes, of which 27 only are functioning. Eight of the functioning boreholes are in Baidoa, 10 are in Kansahdere, 9 are in Berdare, and 1 is in Dinsor. There is no functioning borehole in Burhakabe. In Hiran, borehole drilling began 1915, the total borehole in Hiran are 34. All districts in the Hiran region have at least one functioning boreholes. There are six operational boreholes in Gedo region; these boreholes provide water overpopulation of 3800 permanent households and 42000 of nomadic households (13).

Springs: Springs are surface water discharged from underground water; they are either natural or manmade. They are also the water sources for both humans and livestock. There are 38 natural springs in the Juba basin and 10 in the Shabelle basin.

Irrigation in Somalia

Irrigation is generally defined as an artificial supply of water in order to supplement to precipitation. Somalia has a long history in irrigation particularly in the alluvial plain of Juba and Shabelle Rivers. There were 10 barrages, which fed canals conveying water from the river to remote agricultural lands. Nine of the barrages were in Shabelle River while one of them was in the Juba River. In Jowhar, below the Shabelle River, there were large commercial projects of irrigated sugarcane, banana, citrus, rice and other fruits. There were also other commercial schemes of irrigation for the production of the same cash crops in Jilib below the Juba River. Due to the civil war, most of the irrigation infrastructures destroyed. There are opportunities to rehabilitate old schemes (10).

Pre-war statistics indicate that crop production accounted about 20% of the foreign exchange. There were 15000 ha of surface irrigation and 50000 ha of controlled irrigation along the Juba-Shabelle Rivers. The crops that mainly require irrigation in Somalia are cereal crops, fruit trees, sesame, cowpea, groundnuts, rice, tomatoes and vegetables. There are no reliable data of the irrigated areas. Although there are large agricultural land in the riverine area of both rivers, irrigation is limited. According to Hery (16), the irrigated areas were estimated about 38685 ha, the potential of 65000 ha was in the flood plain of Shabelle River. Likewise, operated irrigated areas were estimated with 73210 ha and the total potential of 221500 ha was in Juba River. When the irrigation infrastructures were functioning, there were several various types of cropping patterns. Most of these cropping patterns practiced on the riverine of Juba and Shabelle Rivers were included; fruit trees, maize, and groundnuts, which were in Gu (Spring) and Deyr (Autumn) seasons; tomatoes, sesame, cowpea, and vegetables in Deyr and Jilaal (Winter) seasons. As the irrigation infrastructures destroyed, most of these cropping patterns are invalid (13).

Rainfall also serves a significant amount of water for agricultural production. Most of the small-scale farmers living away from the riverine areas depend on the rainfall. Most of the cropping patterns in rain-fed agricultural practices consist of sorghum, maize, groundnut, cowpea, and mung-beans. Sesame are also grown in these areas when there is high rainfall but this cropping pattern is only possible in the two rainy seasons (Gu and Deyr). However, some rain-fed farmers had started to discharge the shallow-wells for vegetable production by pressurized irrigation.

Due to the climatic characteristics, crop water use is high, and potential evapotranspiration (PET) is sometimes higher than the precipitation. Annual irrigation demand in Jilib district in the riverine of Juba River is estimated with 11428 m^3 h^1 and similarly, the irrigation demand of Jowhar district is 11830 m^3 h^1. As indicated by the tables (8) given below (Table 1 and Table 2), annual crop water use of Jilib and Jowhar (ET_c) is estimated with 300.2 and 263.4 mm respectively and annual reference evapotranspiration (ET_o) accounts 525 mm in Jilib and 452.7 in Jowhar, respectively. The overall irrigation efficiency of the selected cropping pattern in the riverine agricultural area is 39% (13). The tables given below only indicate selected cropping patterns (maize, groundnut, sesame, vegetable, bananas, citrus, and sugarcane).

Table 1. The water requirement of selected cropping pattern (maize, groundnut, sesame, vegetables, bananas, citrus and sugarcane) in Jilib

Month	ET_o	ET_c	P_{eff}	I_{net}	W_s	I_d	
	mm	mm	mm	mm	$l\ s^{-1}\ ha^{-1}$	$l\ s^{-1}\ ha^{-1}$	$m^3\ ha^{-1}$
Jan	52.1	16.8	0.2	16.6	0.30	0.49	1324
Feb	53.3	10.6	0.0	10.6	0.00	0.00	0
Mar	51.4	13.7	0.4	13.2	0.00	0.00	0
Apr	47.3	20.2	23.4	2.6	0.05	0.08	208
May	42.4	28.3	39.6	0.0	0.00	0.00	0
Jun	38.3	40.8	29.2	11.6	0.20	0.34	908
Jul	36.1	40.9	16.3	24.6	0.44	0.73	1964
Aug	36.3	30.7	7.9	22.8	0.41	0.68	1815
Sep	38.5	14.1	4.3	9.8	0.17	0.29	774
Oct	41.9	18.3	8.6	9.8	0.17	0.29	774
Nov	45.4	31.8	14.5	17.4	0.31	0.52	1384
Dec	42.0	34.0	9.2	24.8	0.51	0.85	2277
Annual	**525.0**	**300.2**	**153.6**	**163.8**	**0.21**	**0.36**	**11428**
Mean	**43.8**	**25.0**	**12.8**	**13.65**	**0.21333**	**0.35583**	**952.3333**

In Table ET_o, reference evapotranspiration (mm); ET_c, crop evapotranspiration(mm); P_{eff}, Effective precipitation (mm); I_{net}, amount of net irrigation (mm) and W_s, water supply (mm); I_d, irrigation demand (mm).

Table 2. The water requirement of selected cropping pattern (maize, groundnut, sesame, vegetable, bananas, citrus and sugarcane in Jowhar

Month	ET_o	ET_c	P_{eff}	I_{net}	W_s	I_d	
	mm	**mm**	**mm**	**mm**	**$l\ s^{-1}\ ha^{-1}$**	**$l\ s^{-1}\ ha^{-1}$**	**$m^3\ ha^{-1}$**
Jan	41.6	13.4	0.2	13.3	0.24	0.39	1,056
Feb	42.9	8.5	0.0	8.5	0.00	0.00	-
Mar	42.1	11.2	0.6	10.6	0.00	0.00	-
Apr	39.7	17.0	19.5	1.9	0.03	0.06	149
May	36.8	24.5	25.8	2.4	0.04	0.07	193
Jun	34.5	36.7	13.3	23.4	0.42	0.69	1,860
Jul	33.4	37.8	6.1	31.8	0.57	0.94	2,530
Aug	34.0	28.7	0.9	27.8	0.50	0.83	2,217
Sep	35.7	13.1	0.2	12.9	0.23	0.38	1,027
Oct	37.8	16.5	15.5	2.4	0.04	0.07	193
Nov	39.5	27.6	19.5	8.1	0.14	0.24	640
Dec	34.8	28.2	6.7	21.5	0.44	0.73	1,964
Annual	**452.7**	**263.4**	**108.4**	**164.5**	**0.22**	**0.37**	**11,830**
Mean	**37.7**	**21.9**	**9.0**	**13.7**	**0.2**	**0.4**	**1182.9**

In Table $ET_{o,}$ reference evapotranspiration (mm); ET_c, crop evapotranspiration(mm); P_{eff}, Effective precipitation (mm); I_{net}, amount of net irrigation (mm) and W_s, water supply (mm); I_d, irrigation demand (mm).

Harvesting rainfall water is also common in Somalia but there are no data and studies indicating the annual amount of harvested rainfall water used for irrigation. Unlined dam locally known as Wars are used for harvesting rainfall water and used the water to feed livestock. Groundwater are recently started to be used as irrigation sources. Urban farming is increasing in and outskirts of the big cities by exploiting shallow wells and applying drip irrigation, but most of the urban farming is restricted vegetable production. Maize and sorghum, which are the country's staple crops and food are still produced in traditional mean, by using flood irrigation and rain-fed. The water requirements of the above-mentioned cropping patterns were all estimated from FAO-Penman-Monteith Method and computed using CROPWAT software. There are no recently conducted experiments, which focused on the relationship between plant, water, soil and atmosphere. There are also no studies related to the quality of the water used for irrigation and their effect on the yield production of the crops.

Conclusion

This work thoroughly reviews the water resources and irrigation in Somalia from the recent and past studies. Southern regions of Somalia were the authors' targeted areas as the two perennial streams originating from Ethiopia pass in southern regions and characterized by higher rainfall comparing to the northern regions.

Juba and Shabelle Rivers are the two main surface water resources in Somalia, particularly in Southern Somalia. The two rivers are considered international rivers as they are shared by Somalia, Ethiopia and Kenya. The annual average runoff of the Shabelle River is 3387 M m^3 from Ethiopia and 2384 M m^3 from Somalia and the annual mean runoff of the Juba River is 6600 M m^3 and 6200 M m^3 from Ethiopia and Somalia, respectively. The Kenya's contribution to the runoff of the Juba River is insignificant. Running distance of the Shabelle River is about 2526 km, the total length of the Juba River is about 1808 km. Boreholes, and dug shallow wells are significant groundwater sources in Somalia. Many communities utilize this groundwater for livestock production.

Somalia is an arid and semiarid climatic zone, rainfall is erratic and low, and it is the only meteorological parameter that indicates the weather changes and the only parameter, which affects the life. The average annual rainfall is estimated at 250 mm, high in south and low in the north. About 60% of Somalia populations depend on the rainfall, the majority of the community farmers who live away from the two rivers practice rain-fed farming. Irrigation infrastructures are undeveloped and most of them destroyed during the civil wars. Pre-civil wars, the irrigation projects were mostly implemented in the areas around the riverine. The irrigation development projects were included in the Fanole dam project, the Juba sugar project (JSP), the Mungab rice irrigation, and the Arare banana project. The experiments related to crop water requirement do not exist and FAO-SWALIM data are the only reliable data for crop water requirement. The annual irrigation demand of Jilib and Jowhar, which both located on the riverbanks are estimated with 11428, and 11830 $m^3 h^{-1}$, respectively, and the annual reference evapotranspiration is 525, and 452.7 mm correspondingly.

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•Chapter-3•

USING TIME SERIES METHOD FOR PREDICTING FUTURE PERFORMANCE of IRRIGATION SCHEMES: A CASE STUDY of ALAŞEHIR IRRIGATION SCHEME

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Abstract

Climate change and drought have many negative effects on agriculture sector especially and relatively on agricultural water management. For this reason, governments make provision for saving water in the agriculture sector. Performance indicators are the best way to monitor irrigation schemes in years and compare among themselves. In this study, some performance indicators are predicted using time series-forecasting method to show the weakness and strengths of a pilot irrigation scheme. Using data for the years 2006-2019, the future performance of the years 2020 and 2021. As a result, the method may help in making water policies, engineers, decision-makers.

Keywords: Forecasting, Irrigation performance indicators, Time series

INTRODUCTION

All over the World, water is consumed mostly in the agricultural sector (Fischer et al., 2007). Water is a crucial source and is limited. In near future, in the following 40 years, it is estimated that the population of the World will increase by 2.5 billion and water demand will also increase to meet the needs of the population. However, the water demand is growing faster than population growth (Godfrey et al, 2010; USIAD, 2007). Therefore, water should be protected for sustainable agricultural production.

Water is mostly controlled by water user associations (WUAs) who are responsible to distribute water from a source to the farmers. In irrigated areas, some organizations are also responsible for water control besides WUAs. In many countries, experts, managers, national planners and decision-makers discuss the improvement of irrigation schemes with the help of a monitoring and evaluation system (Kartal et al, 2020;2019; Arslan and Değirmenci, 2017).

Performance indicators are used to assess irrigation performance of irrigation schemes controlled by WUAs (Molden et al 1998; Burt 2001; Malano et al 2004; Renault et al 2007). Many researchers in Mediterranean countries adopt these indicators and applied in their irrigation schemes such as Spain (Corcoles 2010; 2012; Alcon et al, 2017; Rodriguez-diaz 2004; 2008), Italy (Zema et al, 2015; 2018; 2020), Turkey (Uysal 2010; Kalender and Toprak 2017; Değirmenci et al 2017; Değirmenci 2001; Çakmak et al, 2004; Arslan and Değirmenci 2018).

In Turkey, approximately 65% of the irrigated area are irrigated by surface irrigation (DSI, 2017). Surface irrigation methods cause overuse and uncontrolled irrigation water consumption (Kartal et al, 2019). Turkey, to develop and manage its existing water resources in the best way by considering the balance of protection and use of water, made some plans by 2023. It is called The National Water Plan, determination of Turkey's water available related future policies, improving and savings of water for development (Ministry of Agriculture and Forestry, 2019).

In this study, a WUA is assessed with irrigation performance indicators using the data obtained from State Hydraulic Works (DSI). It is aimed to forecast the future performance of the WUA. Time Series Forecasting Method is chosen to investigate the indicators to help water managers to make policies, plans and see weakness and strengths of the WUA as a pilot irrigation scheme.

MATERIAL and METHODS

In the study, the data between 2006-2019 of Alaşehir Irrigation Scheme were used to estimate future performance selected. Irrigation water requirement, irrigation water diverted, production, irrigated and command area of the system data were obtained from State Hydraulic Works reports. Time series forecasting method is used to forecast performance indicator values for 2020 and 2021. Production performance indicator set was chosen to estimate the future performance of the irrigation scheme. Calculation formulas of the performance indicator set were given in Table 1.

Table 1. Calculating selected performance indicators

Performance indicator	Formula
Output per unit irrigated area (€ ha^{-1})	(Annual total production value) / (Irrigated area)
Output per unit command area (€ ha^{-1})	(Annual total production value) / (Command area)
Output per unit irrigation water diverted to the system (€ m^{-3})	(Annual total production value) / (Annual volume of irrigation water diverted to the system)
Output per unit irrigation water requirement (€ m^{-3})	(Annual total production value) / (Annual volume of irrigation water requirement)

Data analysis

In the analysis of the data, the R program "Forecasting" package was used and the codes used are presented in Table 1. The Time Series offers different models depending on the situation and indicators considered. ARIMA method provides strong estimates with a single indicator (Nelson, 1991; Engle, 1982; Campbell & Diebold, 2005). In the study, the amount of irrigation between the years 2006-2016 is the basic data, so ARIMA method is used for strong estimates. Three steps should be followed to analyze and model time series (Box, Jenkins & Reinsel, 1994): model identification, parameter estimation, and model validity testing. Accordingly, first of all, the most suitable model should be determined with a method. ARIMA is one of the most powerful estimation methods that can be used to determine the most suitable model by comparing different models. ARIMA (*p, d, q*) with fit indices.

Table 1. Codes used for analysis

library(forecast) #### Basic package used for predictions
Y<-**ts**(data$variable, **start** = **c**(year,1), **f**=1)   #### code used in time series generation
autoplot(Y) ### the code used to chart the time series
fitarima<-**auto.arima(**Y, **stepwise**=F, **approximation** = F, **trace** = T, **seasonal** = F) ### Code used for modeling with ARIMA
checkresiduals(fitarima) #### code used to check residuals of the model
fc<- **forecast**(fitarima, **h**=5) #### the code used for forecasting
plot(**fc**, **main**="…", **ylab**="…", **xlab**="…") #### The code used to draw the forecast chart
print(**summary**(fitarima)) #### The code in which the outputs of the modeling made with ARIMA are printed
print(**summary**(fc)) #### the code used to print the predicted values

Bayes Information Criteria (BIC) and some goodness of fit statistics are used to determine the most suitable model. BIC is an index used in Bayesian statistics to compare which model is the best fit between two or more models (Neath & Cavanaugh, 2017). R makes this comparison and presents the most suitable model. In the estimation of parameters, the maximum probability that is asymptotically correct for time series is obtained (Mandal, 2005). In this study, R program was used for time series creation, parameter estimation and estimation. Analyses were carried out with the following codes.

RESULT AND DISCUSSION

Model information, fit indices and forecast findings for each performance indicator are presented in Table 2. The most suitable ARIMA model for the Unit Irrigated area production value (0,1,0), For the unit irrigation area production value (0,0,1), For the unit irrigation water production value taken into the network (0,0,1) and Unit irrigation (0,1,0) was obtained for the production value against the water need. The estimates made for the years 2020-2021 are presented below in Table 3, respectively. In the table, there is two confidence interval, 80% and 95%. And, forecast the highest and lowest value of performance indicators are shown as lower and upper for the confidence intervals. When confidence interval value increase, forecasting accuracy increase but interval value expands too.

Table 2. Compliance statistics

Indicators	Compliance statistics					
	RMSE	MAPE	MAE	Normalized BIC	llike	Model
Output per unit irrigated area (€ ha^{-1})	2765.95	18.18	2260.42	190.14	93.92	ARIMA(0,1,0)
Output per unit command area (€ ha^{-1})	517.67	22.79	457.85	177.56	85.18	ARIMA(0,0,1)
Output per unit irrigation water diverted to the system (€ m^{-3})	0.20	28.86	0.16	3.62	1.79	ARIMA(0,0,1)
Output per unit irrigation water requirement (€ m^{-3})	0.40	42.08	0.31	13.61	5.66	ARIMA(0,1,0)

Output per unit irrigated, in 2020, was forecasted as 15075.74 € ha^{-1}, and expected between 3704.08 € ha^{-1} and 26447.20 € ha^{-1} in 95% confidence interval when these value forecasted as 15075.64 € ha^{-1}, 2361.85 43 € ha^{-1} and 27789.43 € ha^{-1} in 2021, respectively. Output per unit command area, in 2020 and 2021, was forecasted as 2212.82 € ha^{-1}, and expected to be between 1220.43 € ha^{-1} and 2212.82 € ha^{-1} in 95% confidence interval.

Output per unit irrigation water diverted to the system, in 2020 and 2021, was forecasted as 0.59 € m^{-3}, and expected to be between 0.26 € m^{-3} and 1.10 € m^{-3} in 95% confidence interval. Output per unit irrigation water requirement, in 2020 and 2021, was forecasted as 0.27 € m^{-3}, and in 95% confidence interval, was expected to be between 0.82 € m^{-3} and 1.93 € m^{-3} in 2020, and between 0.82 € m^{-3} and 2.13 € m^{-3} in 2021.

In Turkey, in the most comprehensive study of Arslan et al (2020), show output per unit irrigated/command area are found as 6486.8 € ha^{-1} and 2468.3 € ha^{-1} for average in the years 2011-2015. When current studies values are compared with the average values of Turkey, Alaşehir's irrigation performance values are high. Main crops generally consist of wine yards which production value is quite high. And, in future Alaşehir show better performance when its values compared with the average values of Turkey.

Kartal and Değirmenci (2019), in 5 irrigation schemes in Kahramanmaraş, Turkey, indicated an average of output per unit irrigation water diverted to the system and Output per unit irrigation water requirement as 0.33 \$ m^{-3} and 0.65 \$ m^{-3} in the years 2006-2016. In Kahramanmaraş, different kind of crops are cultivated on irrigated areas, Alaşehir Irrigation scheme shows better performance for output per unit irrigation water diverted to the system with the value 0.59 € m^{-3}.

Table 3. Estimations of selected performance indicators for the years 2020-2021

	Output per unit irrigated area (€ ha^{-1})				
	Lower 80%	Lower 95%	**Forecast**	Upper 95%	Upper 80%
2020	7640.17	3704.08	15075.64	26447.2	22511.1
2021	6762.54	2361.85	15075.64	27789.43	23388.74
	Output per unit command area (€ ha^{-1})				
	Lower 80%	Lower 95%	**Forecast**	Upper 95%	Upper 80%
2020	1220.43	695.1	2212.82	3730.53	3205.2
2021	1220.43	695.1	2212.82	3730.53	3205.2
	Output per unit irrigation water diverted to the system (€ m^{-3})				
	Lower 80%	Lower 5%	**Forecast**	Upper 95%	Upper 80%
2020	0.26	0.08	0.59	1.1	0.93
2021	0.26	0.08	0.59	1.1	0.93
	Output per unit irrigation water requirement (€ m^{-3})				
	Lower 80%	Lower 95%	**Forecast**	Upper 95%	Upper 80%
2020	0.82	1.39	0.27	1.93	1.36
2021	0.95	1.59	0.27	2.13	1.49

Figure 1 shows the predicted values in confidence intervals for 95% in grey and 80% light grey. There is no linear increase in all performance indicators for the years 2020 and 2021. However, there is a possibility for higher performance and vice versa. Performance indicators show inconsistent increase and decrease in years.

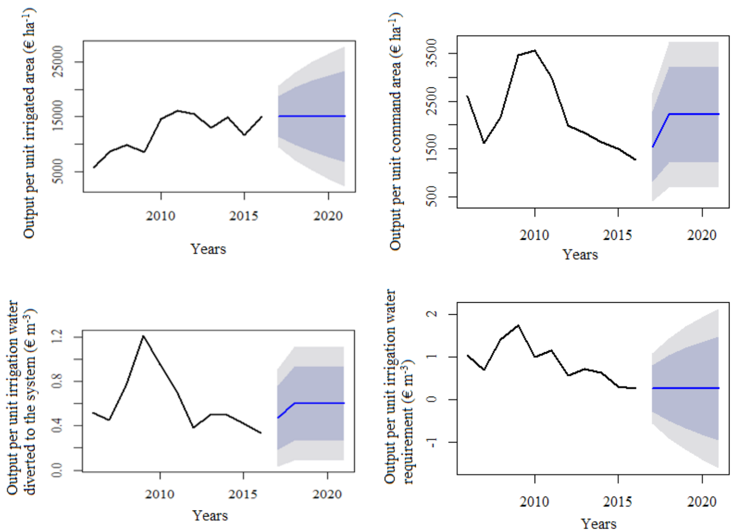

Figure 1. Time series-forecasting graphs of selected performance indicators

CONCLUSION

The study presents a methodology to forecast the future performance of irrigation schemes. Time series-Forecasting method is chosen and applied on an irrigation scheme. Turkish irrigation schemes don't show consistent performance, for this reason, to reach the national targets to catch modern management, operation and maintenance for future, this method may be used. Performance indicators are useful tools to assess irrigation schemes. Prediction of irrigation performance indicators may help to improve water policies, give ideas to understand the weakness and strengths of irrigation schemes for the future. In the future, following this work, this method can be applied to other irrigation schemes and may compare with the targeted values of performance indicators.

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•*Chapter-4*•

SEED PRETREATMENTS TO OVERCOME DROUGHT STRESS DURING GERMINATION FOR BIOLOGICAL RECLAMATION of DESERT AREAS

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INTRODUCTION

Use of desert plant species has a main role in the restoration of arid and semi-arid areas (Huang and Gutterman, 2003). The Asian desert the average annual rainfall is between 200 and 30 mm, or even less (Fu 1989) It is very apparent that the effects of human activities and livestock on these areas have the severely limited tree and shrub growth in some regions. overdraft and grazing have drastically reduced the extent of many forests throughout some of the country, and sufficient consideration of plant's success rate, especially seedling vigor, must be made prior to re-planting efforts (El-Moslimany.1986).

Almost all desert plant species regenerated by seed and the success of the establishment of the species into a new area depends on seed dispersal, germination and, establishment of seedlings. For example, *Calotropis sp* as a desert plant produces lots of small seeds which are dispersed by wind but has a low density per unit area because its germination stage is sensitive to drought stress (Bazrafkan 2011). Seed germination in the plant life cycle is the critical stage for survival, especially under arid and unpredictable environmental conditions like those of the Mediterranean ecosystems (Gimmenez-Benavides et al., 2005). Seed quality and uniformity of germination are limiting factors in the restoration of shrubs and forest trees (Fenner, 1992). Poor germination and low seedling establishment are regarded as the major causes of low densities in Mediterranean forests (Close and Wilson, 2002). Several environmental factors can influence germination (Bewley and Black, 1994). Germination is one of the sensitive to environmental stresses, particularly salinity stress, even tolerant plants to drought and salinity stress during germination and seedling establishment are sensitive to salinity stress. Various environmental stresses viz. high winds, extreme temperatures, soil salinity, drought and, flood have affected the germination of the seed, among these soil salinity is one of the most devastating environmental stresses, which causes major reductions in seed germination (Yamaguchi and Blumwald, 2005; Shahbaz and Ashraf, 2013). Thus, any study of dryland restoration should ideally separate the effects of individual environmental factors and their interactions on demographic stages. Seed performance of these plants in semi and the semi-arid areas also depends on the seed vigor (Copland and McDonald, 1995). Early vigor is a combination of the ability of the seed to germinate uniformly and emerge after sowing, and the ability of the young plant to grow and develop after emergence (Hou and Wang, 2002). Seeds, especially with low vigor, sown in cold spring are often exposed to numerous environmental hazards during germination. Temperature and moisture levels appear to be critical the germination and emergence stage (Bodsworth and Bewley, 1981). Water content of the soil is an important factor for control of seed germination (Kramer and Kozlowiski, 1979). In dry forests, germination and early establishment must occur during the first of the wet season when water is more available (Khurana and Singh, 2000). Seed priming is a pretreatment that partially hydrates seed, in order to just start germination processes, but not radical emergence (Welbaum et al., 1998).

Improving seed germination at low temperatures in the early spring with osmo-priming (especially with PEG solutions) may be of great practical importance particularly in Mediterranean environments. Seed priming is a method controlled of seed hydration that necessary metabolic activities occurred for germination but radicle emergence is unallowed (Bewley and Black 1982). There is a lot of debate about cell cycle activity during seed priming. Some researchers have reported that primed seeds increase their synthesis of DNA and RNA (Lanteri etal 1997, McDonald 2000), whereas some others reported differences in the reaction to the priming treatment for various species and seed lots (Gurusinghe et al 1999, Sliwinska and Sadowski, 2004). But there are more reports about the positive effect of priming on seed germination and germination uniformity under stress conditions. The beneficial effects of priming on the germination capacity and vigor of the seed were most probably due to stimulation of metabolic activities in the embryo i.e., synthesis of nucleic acids (DNA and mRNA), protein production, repair of the cell membrane (. Bewley,1997; McDonald, 2000; Jowkar, 2012) and induction of biochemical changes such as breaking of dormancy, hydrolysis of inhibitors and enzymes activation (Wattanakulpakin et al, 2012). Numerous studies have been performed to exhibit the considerable effectiveness of hydro-priming on germination and seedling growth in many crop species, e.g., barley (Judi and Sharifzadeh, 2006), chickpea (Ghasemi- Golezani etal, 2008), and sugar beet (alipor etal 2019). Priming of seed in osmotic solution has been used to improve the rate and uniformity of germination of wheat (*Triticum aestivum* L.) and barley (*Hordeum Vulgare* L.) (All-Karaki, 1998). Priming of seed in osmotic material or water may improve germination and emergence (Ashraf and Abu-Shakra, 1978) and promote vigorous root growth under low soil water potential compared to control (Carceller and Soriano, 1972). Primed seed with PEG 6000 exhibited increased germination rate of the three herbage kinds of grass at low temperatures (Mauromicale and Cavallaro, 1996). Taghvaei and bazrafkan, (2014) reported that priming increased the rate and germination percentage of *Calotropic Procera* Seed.

Although the *Haloxylon aphyllum* L. is one of the most dominant species of Asian dune deserts, there is little information about the seed germination responses of its to water stress and there is no data on the recovery rate of seed from water stress-induced osmotically. We need anyway to improve the germination rate and performance of seedling. The aim of this research was to study the effects of water stress on germination and seedling vigor and response of recovery under water stress conditions for the improvement of water stress tolerance of *Haloxylon aphyllum* L.

Effects of osmo-primiming on Germination percentage (GP)

Haloxylon aphyllum L. is a leaf succulent perennial shrub belonging to the family of Chenopodiaceae (Ali and Qaiser, 2001), which is widely distributed in Turkey, Syria, Iraq, Iran, Afghanistan, Kashmir, India, and central Asia (Jafari, 1966). In Iran, this plant is mainly distributed in Dune deserts of Fars (Neirize) provenance, the center of Iran in the Asian desert. Iran is located in the mid-latitude belt of arid and semi-arid regions of the Earth. Although the *Haloxylon aphyllum* L. is one of the most dominant species of Iran dune deserts, but sensitive to drought stress in the germination stage (Taghvaei and ghaedi, 2014). For this experiment, they have sown the *Haloxylon aphyllum* seed from two provenances or seed source (0.0, -0.3, -0.6, -0.9, -1.2, -1.5 MPa) of PEG solation at 25ºC (Taghvaei, 2010). For seed priming, Half of seeds were primed in critical PEG potential (-1.2 MPa) for 3 days at 25ºC (Gaedi et al., 2009), where seeds imbibed but did not germinate (Bradford, 1986). Then seeds were washed with distilled water. Experiments were carried out at the Department of desert Region Management, College of Agriculture, University of Shiraz, Iran. Seeds were treated using the 0.2% fungicide Benomyl before the germination test. They reported that the germination percentage of *H. aphyllum* seeds was significantly ($p<0.01$) affected by osmotic potential. The germination percentage of *H. aphyllum* decreased with the decrease of osmotic potential. There was also a noticeable decrease in germination percentage at -0.6 MPa (Table 1), since germination percentage decreased from 92% (in control) to 56.6% (in treatment with -0.6

MPa). No seed germination was observed in -0.9 MPa (Table 1). Priming with PEG for 3 days improved germination percentage. Overall final germination percentage was comparable in both non-primed and primed seed in the case of control and treatment with -0.3 MPa, but germination percentage in primed seed was significantly greater than non-primed seed when -0.6 MPa was applied (Fig 1). Germination occurred in -0.9 MPa in primed seed but no germination was in non-primed seeds (Table 1).

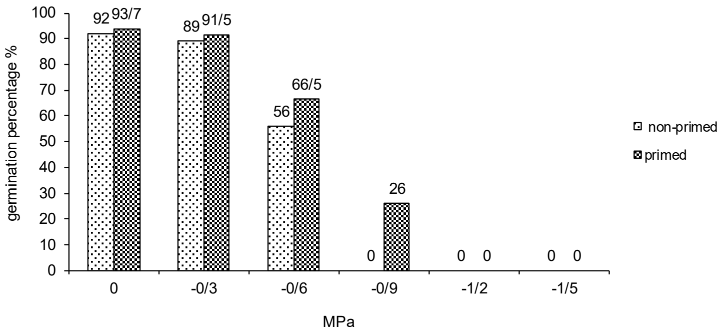

Fig1: Germination percentage (GP) of *Haloxylon aphyllum* L. seeds in response to osmotic stress

Table 1. Variations in seed and seedling parameters among osmotic potential levels

Osmotic potential (MPa)	G%		MTG(hour)		GR(seed/hour)		SL(cm)		SDW(g)	
	n.p	p	np	.p	n.p	P	n.p	p	n.p	.p
0	92	93.7	51.8	29.98	0.51	0.81	3.8	47.78	0.003	0.0035
-0.3	89	91.5	58.9	30.29	0.41	0.79	1.94	4.61	0.002	0.003
-0.6	56	66.5	124.5	45.73	0.19	0.53	0.856	3.53	0.001	0.002
-0.9	0	29	0	62.60	0	0.38	0	1.96	0	0.001
-1.2	0	0	0	0	0	0	0	0	0	0
-1.5	0	0	0	0	0	0	0	0	0	0
	39.58b	43.45a	39.22a	28.10b	0.186b	0.418a	1.09b	2.48a	0.001b	0.00158a

Means with the same letter on each column are not significantly different ($p<0.05$)

P: primed seed, N.P: non primed seed, G% = germination percentage, GR = germination Rate (per day), MTG = Mean of Time germination, SL = Seedling Length (cm), SDW = Seedling Dry Weight (g),

Effects of osmo-primiming on Germination rate (GR)

Osmotic potential affected significantly ($p<0.01$) the germination rate . The average of germination rate in control was 0.51 (seed/hour), but it decreased by 0.19 (seed/hour) in -0.6 MPa (Table 1). Priming significantly improved the germination rate (Fig 2). The average germination rate in control for non–primed seed was 0.51 (seed/hour) while in seed primed was 0.81 (seed/hour). The germination rate of seed primed was significantly greater at -0.3 MPa and -0.6 MPa than non-primed seed (Table 1).

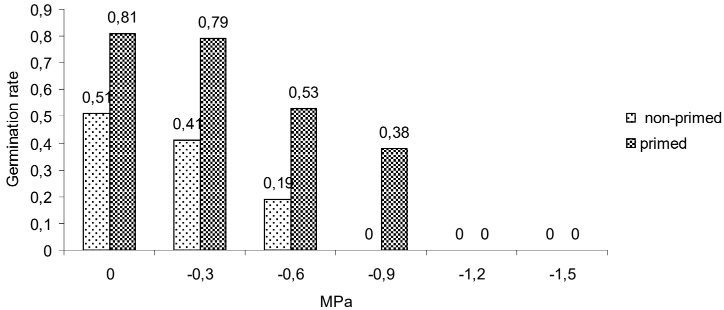

Fig 2: Germination rate of *Haloxylon aphyllum* L. seeds in response to osmotic stress

Effects of osmo-primiming on Mean germination time (MGT)

Mean time to full germination significantly ($p<0.01$) increased by decrease of osmotic potential. In non-primed seeds the osmotic potential treatments of -0.3 MPa to -0.6 MPa increased the time to full germination from 51.87 to 58.9 and 124.49 (hour), respectively (Table 1). Priming with PEG significantly decreased of duration of germination (Fig 3). The duration of germination was shorter in primed seed (29.98, 30.29 and 45.73 hour), than non-primed seed (51.87, 58.9 and 124.49 hour) in control, -0.3 and -0.6 MPa, respectively (Table 1).

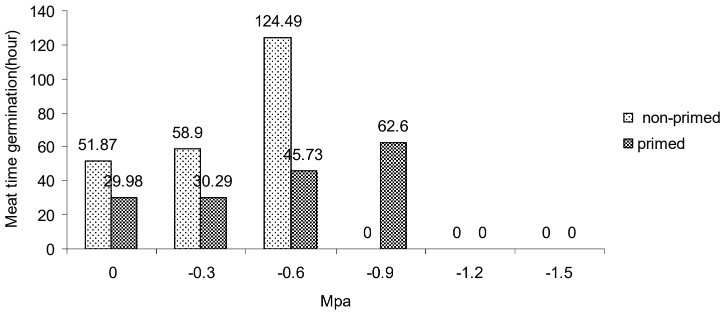

Fig 3: Mean time to full germination (MTG) of *Haloxylon aphyllum* L. seeds in response to osmotic stress

Effects of osmo-primiming on Seedling length (SL)

The seedling length was significantly affected by osmotic stress treatments. The average of seedling length in control was 3.8 cm but at -0.6 MPa it was only 0.8 cm(Table 1). The priming increased the length of seedling significantly. ($P<0.01$) in all level of osmotic potential studied. However, there was no significant difference between control and -0.3 MPa in primed seeds (Fig 4).

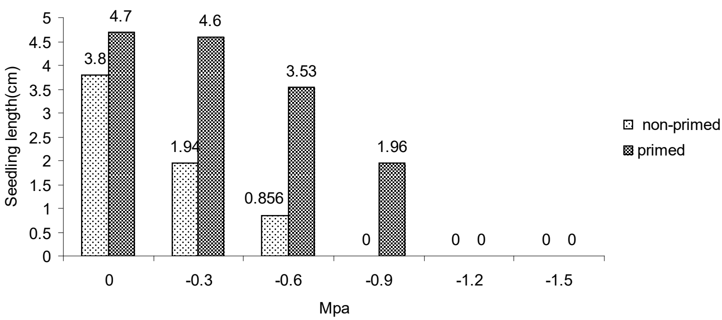

Fig4: *Haloxylon aphyllum* L, seedling length (SL) response to osmotic stress

Effects of osmo-primiming on Seedling dry weight (SW)

Osmotic stress treatments significantly (P<0.01) decreased seedling dry weigh. Seedling dry weight decreased as the osmotic potential decreased (Table 1). The average of seedling dry weight in control was 0.003 g but decreased to 0.0002g at -0.6MPa. Priming for 3 days significantly (P<0.01) increased seedling dry weight compared to non-primed seeds (Fig 5). There were no significant differences in the seedling dry weight between primed seed and non-primed seed in control treatment (Table 1).

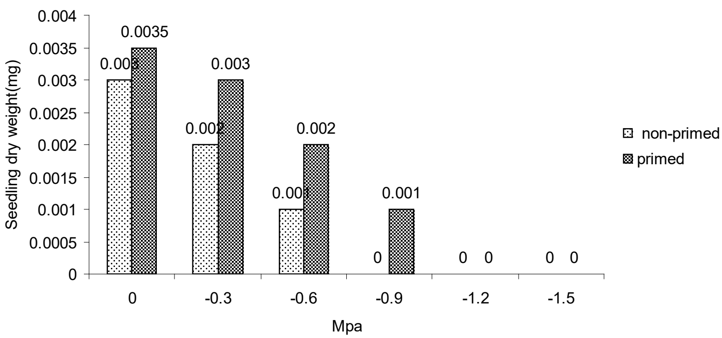

Fig 5: *Haloxylon aphyllum* L. seedling dry weight (SDW) response to osmotic stress

Effects of osmo-primiming on Threshold of tolerance germination to drought stress

Threshold some methods have been developed previously to describe the relative productivity of species in response to stress, but among these methods the regression method is a specific for show response to salinity stress in plants (Taghvaei, 2008; Covell et al., 1986). Regression analysis is generally recognized as the best statistical tool for detection of relationships among relative germination and water stress. The germination data collected from 0.0 (control) to -0.9MPa osmotic potentials were used to construct two linear regressions to describe the decreases and threshold limit of germination in osmotic stress condition. The results showed a negative trend between drought stress and relative germination (Figure 6). Germination relativity was slightly reduced to 0.3Mpa, but after that it decreased with a large slope. Drought tolerance threshold of seedling traits was also influenced by seed priming. Priming with PEG (-0.9 MPa for 24 h) increased threshold to drought tolerance in the germination phase. So that the tolerance threshold of germination relativity increased from 0.3 MPa (in non-primed seed) to 0.6 MPa in primed seeds (Figures 6 and 7).

The priming increased the threshold limit of germination for the osmotic potential of *H. aphyllum* L. seeds (Fig 6,7). The highest values for germination were obtained at control in non-primed and primed seed, however, decreased with a decrease of osmotic potential (Fig 7). In the non-primed seed germination suddenly decreased at -0.3 MPa (Fig 6) but the primed seed showed this suddenly slope at -0.6 MPa (Fig 7).

The intersection of the two lines between 0 to -0.3, and -0.3 to -0.9 MPa, and between 0 to -0.6 and -0.6 to -1.2 MPa showed a threshold limit in germination to the osmotic potential for non-primed (Fig 6) and primed (Fig 7) seeds respectively.

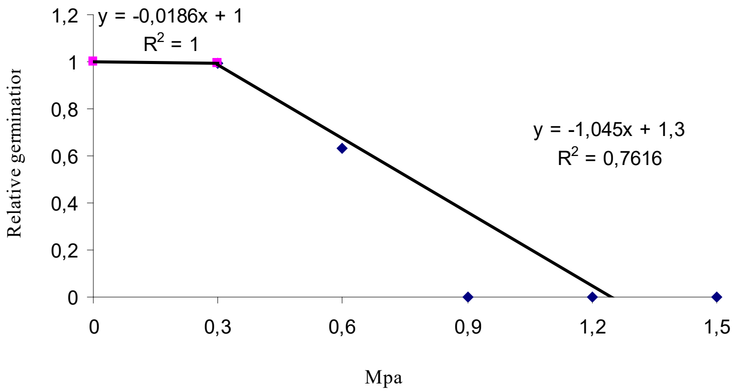

Fig 6: *Haloxylon aphyllum* L. relative germination response to osmo-potential before primed

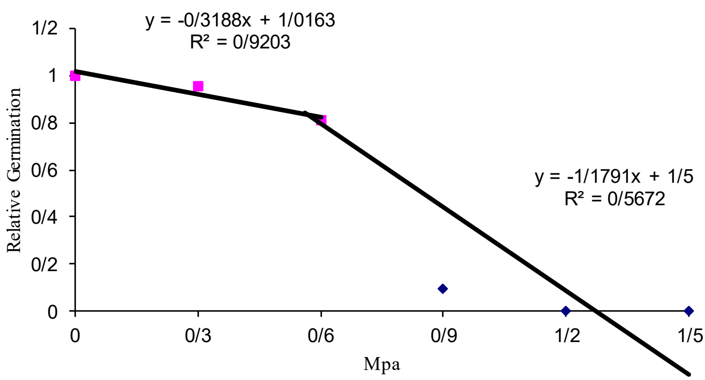

Fig7: *Haloxylon aphyllum* L. relative germination response to osmo-potential after primed

DISCUSSION

The initial germination of *H. aphyllum* is sensitive to osmotic stress. increasing osmotic potential reduced the germination traits significantly. Osmotic potential of PEG solution reduced germination percentage, germination rate, seedling length, and seedling dry weight. Similar findings were reported about other halophytic species (Khan and Rizvi, 1994, Tobe et al., 2000). Germination of *H. aphyllum* decreased with an increasing osmotic potential and was inhibited at the highest osmotic potential (-0.9 MPa). high osmotic potential decreases the water uptake of seed, thereby inhibits the germination (Dodd and Donovan, 1999; Katembe et al., 1998). The second phase of water uptake involves the movement of water across the cell membranes of the seed depends on the osmotic potential of the surrounding solution (Bewly and Black, 1994). Osmotic priming of *H. aphyllum* L. seeds increased of germination percentage, germination rate, seedling length, and seedling dry weight. The seed of *H. aphyllum* L. remained viable after 3 days under -1.2 MPa osmotic stress. The priming has a beneficial effect on seed vigor. Similar finding was reported about *Atriplex* species (Katembe *et al.,* 1998).There are reports that priming permits early DNA replication (Bray *et al*., 1989), increased RNA and protein synthesis (Ibrahim *et al*., 1983), resulted in greater ATP availability (Mazor *et al*., 1984), and faster embryo growth (Dahal *et al*., 1990), repair of deteriorated seed parts (Giri *et al.,* 2003) compared with control.

CONCLUSION

In an arid environment, rapid germination and early seedling vigor tend to maximize the use of available soil water after winter, resulting in increased dry matter accumulation. In this area the temperature increase rapidly and soil water evaporates, resulting in higher osmotic potential, a limited duration for germination, decreased germination percentage, and standing seedling per land. In this study, it was demonstrated that the germination of halophytic plant is sensitive to osmotic stress. Therefore, although some times of them produces a large number of healthy and mature seeds with high vigor, but due to the high concentration of salinity in the upper soil layer in these areas, only a small number of them germinate, so the density of these plants in these areas is very low. And we see wind erosion in this area because the low cover of these plants cannot reduce the wind speed. Our results showed that halophytic plant seeds should be harvested by hand after maturation and before shedding then priming should be done on them and the area is sown with primed seeds to increase the chances of establishing halophytic plants.

ACKNOWLEDGMENT
we thank Ms. Masoumeh Ghaedi for collecting data

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•Chapter-5•

CONJOINT ANALYSIS and APPLICATIONS in AGRICULTURE

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INTRODUCTION

Conjoint analysis is a method used by researchers to predict what kind of decisions consumers will make about products using a survey. The main idea is to calculate different properties of a product for any purchase decision and determine the importancy level of properties. With this information, the characteristics of the products or services that are very important can be targeted and future production can be designed. Subconsciously, one person may be more price sensitive, when the other may be more characteristic oriented. Sensing which features are significant and which are insignificant is the goal of the conjoint analysis. The data obtained via surveys are then converted into numbers and managed by statistical analysis.

As a word, conjoint analysis means “collective participation”. The word conjoint was created by combining the words CONSidered and JOINTly (Orme, 2010). The method, which is included in Turkish as “Conjoint Analysis”, is also referred to as “Analysis of Relationships” or “Association Analysis”, “Combined Analysis” or “Integrated Analysis Method”. Conjoint analysis was developed from the need to analyze the effects of predictable factors (features we identify) that can often be measured and whose properties can be based on precise judgments (Green & Srinivasan, 1978). In real life, people reveal their preferences through choices. The sum of the elections forms of demand for goods and services, voting for political candidates, and other interests. It is important to understand how changes in the characteristics of choosing for themselves affect preferences and to anticipate human choice. Aformentioned fields include psychology, economics, environmental science, geography, management, marketing, political science, recreation and transportation. Conjoint analysis is a multivariate market research technique that reveals the importance level of criteria such as efficiency, price and adaptation, which are essential in consumers' usage habits and preferences (Raghavarao et al., 2011).

The conjoint survey question is an advanced question type that market researchers use to present many combinations of product attributes like features, cost, brand, etc. Based on the respondents' answers, market researchers can find out the most liked features by customers and get an idea of pricing. Many times a purchase involves evaluating several parameters that make it complicated. In such a situation, running a conjoint analysis survey can help understand customer psychology. Advantages of conjoint analytics in surveys are competitive analysis, easy experimentation and better branding and marketing strategy. Conjoint analysis can understand how your target audience perceives various product attributes and brands. Market researchers can show different combinations of attributes and determine which product or service is likely to be the most successful in the market. This experimentation gives a lot of insights into customers' preferences at a low cost. Once you know what customers are looking for and are likely to buy, you can better formulate your marketing strategy.

The aim of the study is to present theoretical information about the conjoint analysis and to introduce applications in the field of agriculture.

2. CONJOINT ANALYSIS

Conjoint analysis is a choice modeling research method to understand how people make purchasing decisions. In the real world, we often encounter situations when we have to make tough choices between various alternatives. The conjoint analysis question helps us understand what is essential for your target audience. It involves how they make trade-offs and what essential features they are not willing to let go.

Let $y_{x1x2\ldots xn}$ be the response or transformed response of the concept profile $(x_1,x_2,\ldots,x_n)$ of any choice set S_l. With a full factorial design, we model $y_{x1x2\ldots xn}$ by

$$y_{x_1x_2\ldots x_n} = \mu + \sum_{i=1}^{n} \alpha_{x_i}^{A_i} + \sum_{\substack{i,j=1 \\ i\neq j}}^{n} \alpha_{x_ix_j}^{A_iA_j} + \sum_{\substack{i,j,k=1 \\ i\neq j\neq k\neq i}}^{n} \alpha_{x_ix_jx_k}^{A_iA_jA_k} + \cdots + \alpha_{x_1x_2\ldots x_n}^{A_1A_2\ldots A_n} + e_{x_1x_2\ldots x_n} \quad (1)$$

where μ is the general mean; $\alpha_{x_i}^{A_i}$ is the effect of factor A_i at the x_i level; $\alpha_{x_ix_i}^{A_iA_j}$ is the effect of factors A_i and A_j at x_i and x_j levels, respectively; ... , and is the iid (independently and identically distributed) random error. Under the diagnostic paradigm, composition rules used by decision makers are inferred by determining which terms of Eq.1 are statistically significant. For example, a significant two-way interaction implies that a decision maker considers levels of one factor when determining how much weight to assign to another factor in making an overall judgment. Rather than infer the composition rule used to combine information, discrete choice experimentation methodologies typically assume a composition rule and infer partworths as the effects of the corresponding ANOVA (analysis of variance) model. For example, a linear model that includes brand and attribute effects may be represented as

$$y_{jx_1x_2\ldots x_n} = \mu + \alpha_j^B + \sum_{i=1}^{n} \alpha_{x_i}^{A_i} + e_{x_1x_2\ldots x_n} \quad (2)$$

where α_j^B is the attribute whose levels are the different brands. Assuming Eq.2 implies that the researcher believes two-way and higher-order interactions of the attributes are negligible. The error term of Eq.2 includes that of Eq.1 and variation due to possible misspecification (Raghavarao et al, 2011).

Three primary systems are available: traditional full-profile conjoint analysis, adaptive conjoint analysis, and choice-based conjoint.

2.1. Traditional Full-Profile Conjoint Analysis

Full-profile conjoint has been a mainstay of the conjoint community for decades. Academics have suggested that the full-

profile approach is useful for measuring up to about six attributes (Green and Srinivasan 1978). That number varies from project to project depending on the length of the attribute level text, the respondents' familiarity with the category, and whether attributes are shown as prototypes or pictures. Full-profile conjoint analysis may be used for paper-and-pencil studies, whereas adaptive conjoint analysis must be administered via computer. Full profile conjoint can also be used for computer-assisted personal interviews and internet surveys.

2.2. Choise based conjoint analysis

This type of analysis question asks respondents to imitate their purchasing behavior while answering the survey. The respondents submit responses based on the actual products they would choose in real-life, given specific prices and features. The choice-based conjoint analysis, also known as discrete-choice conjoint analysis, is the most commonly used type of conjoint analysis survey question.

2.3. Adaptive conjoint analysis

This type of conjoint analysis is used in surveys when there are many product features. Researchers generally use it to identify key features that should be included in the product and not the best choice for determining the price. For instance, the surveyor asks respondents to select their relative preference from several attributes. They assess each pair on a grade point scale.

3. RELATED WORKS

In a survey study conducted by Nelson et al. (2005) in Haiti, they examined the market potential for locally produced honey roasted peanuts in Haiti using conjoint analysis. According to the results of the research, it has been determined that the price is the most important feature.

In the study of Patıl et al. (2005), they determined the impressions of the farmers and seed sellers about the public and private sector seed companies in Karnataka. In order to examine the seed preferences of the farmers, conjoint analysis was performed by using the seed price, brand name, seed availability timing and payment method of the seed feature factors. It has been concluded that many farmers consider seeds in the public sector to be reasonably priced and of good quality. However, they generally complained about the poor services of the public sector. As a result of the analysis, the farmers gave the utmost importance to the price, followed by seed availability and brand name in their seed purchase decisions.

In their survey study, Sydorovych and Wossink (2008) applied conjoint analysis to determine the economic, social and ecological characteristics perceived as important for agricultural sustainability by different stakeholders (farmers and scientists) and to evaluate their relative impact on the overall sustainability measure (Fig. 3.1).

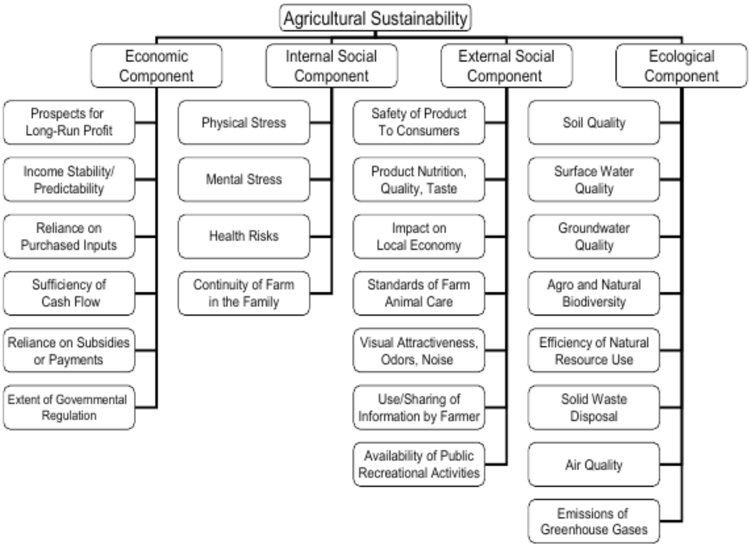

Figure 3.1. Features of agricultural sustainability

According to the results of the survey, the long-term profit expectation in economic sustainability determines that the most important internal social feature is the mental stress level and the continuity of the farm in the family in terms of ecological characteristics.

Cankurt et al. (2009), in a face-to-face study with random sampling in Aydın province, tried to determine the tractor preferences of farmers. In this survey study, according to the importance level of conjoint analysis, by taking the first place with 35.64% - durability, with 28.85% - brand value, 21.60% - fuel consumption and 13.95% tractor price were determined.

In a survey study conducted by Claret et al. (2012) in Spain, they examined the factors that affect the consumers' decision to buy fish - the origin, storage conditions, price and method of obtaining the fish. According to the results of conjoint analysis, the order of importance was found as 42.96% the origin of the fish, 20.58% storage conditions, 19.31% price and the method of obtaining it - 18.01%.

In the survey study of Annunziata and Vecchio (2013) conducted in Italy, four properties of probiotic functional foods were examined, namely "whether they are a basic product or not", price, brand and health benefits. According to the results of the conjoint analysis, "whether it is a basic product or not" with 34% is the most important feature, brand with 28%, its health benefit with 22% and price with 16% was found.

Hanis et al. (2013) in their conjoint analysis in Malaysia examined the sea fish demand and willingness to pay. According to the results of the research, it was determined that the consumers 59.79% give weight to the freshness, 22.27% to the package and 17.94%.to the place where it is sold.

In their study, Takeshima and Nagarajan (2015) estimated how farmers' willingness to pay for seed varies depending on the timing of purchase using both the revealed preference and stated preference models. The results show that the request for payment varies according to the schedule. While low-income farmers in Nigeria may choose to pay a premium price for cowpea seeds if these seeds can be made closer to the planting season, most high-income farmers can pay the same price regardless of schedule. The implications of the study for future research needs are discussed.

In their survey study conducted in Kahramanmaraş, Kızıloğlu and Kızılaslan (2016) examined the fertilizer use, method and information acquisition status of the farmers, taking into account the good agriculture and environmental factors. According to the results of the face to face survey, it was determined that there is no efficient and conscious fertilization in the region, the general tendency is to give fertilizer to the soil without soil analysis, and there is a serious lack of training and publication in fertilizer and fertilization.

In the conjoint analysis conducted by Özel and Ceylan (2016) in Ankara, it was examined to what extent consumers gave importance to the features determined in their ice cream preferences. According to the results of the research, it has been determined that the brand image is important for a conscious consumer group, but ice creams with cheap prices are purchased.

In the study conducted by Adalıoglu et al. (2017) in Aydın province and Soke district, they examined which features such as price, yield, cotton gin, fiber quality, earliness and disease resistance were taken into consideration by cotton producers when purchasing seeds. According to the results of the research, it has been determined that the first factor they care most in variety selection is the cotton gin with a rate of 21.31%, the second is the seed price with the rate of 18.69% and the least important factor is earliness with 12.06%.

In the research conducted by Baki et al. (2017) in İzmir in 2014 through vis-a-vis interviews, consumer preferences for strained pine honey in İzmir province were examined. According to the results of the conjoint analysis, it was determined that the most important factor determining the preference of strained pine honey was the place where honey was purchased (38.48%), followed by the region where honey was produced (%30.65), label(% 11.60), price (%10.88) and color (%8.39) factors.

According to proportional sample size method study contucted by Ormeci Kart et al. (2017) in Turkey's major potato producing areas, Nigde and İzmir, they tried to define preferences for seed potato producers. According to the results of the conjoint analysis, they determined that the first important factor is the industrial type, that the marketing options affect the seed options and that the disease resistance comes after the yield performance when buying seeds.

In a survey conducted by Sánchez-Toledano et al (2017), in Chiapas, Mexico, they examined the willingness to pay as a determinant in the selection of newly developed corn seed and land varieties. According to the results of the research, it was determined that the newly developed seed varieties were preferred over the traditional Creole variety, and this way the variety with higher yield, disease resistance and larger leaf width was preferred.

In Toklu's (2017) study on sunflower oil, the data obtained from face-to-face interviews with 211 consumers selected by sampling method were evaluated by conjoint analysis. Different levels for characteristics such as producer and cooperative levels for the brand, organic and conventional levels for the production method, domestic and foreign levels for the country of origin, 21 Tl, 26 Tl, 32 Tl for the price feature are defined. The order and levels of preference of these four features are listed as follows: local origin, 21 Tl price for 5 liters, organic production and producer brand.

In a study conducted by Ayhan and Armagan (2018) with 119 producers selected by the stratified random sampling method in Soke, Germenjik and Kocharlı districts of Aydın province, they examined the importance levels of yield, quality, durability and price criteria that affect the selection of cotton producers and their willingness to pay for additional cotton seed. Here, it was determined that quality is 28%, efficiency is 25%, price is 24% and durability is 23%.

Kibar and Mikail (2018) in their study tried to define consumers' preferences for the red meat in Siirt Province. The paper illustrated the conjoint analysis application in determining consumers' preferences for the attributes of red meat according to the amount of consumption. Multiple regression analysis used for determination most valued attributes and their levels. A random sample of 160 red meat consumers was interviewed in Siirt Province. For the survey portion of the interview, respondents were asked to assess the importance of the following attributes: meat type, purchasing sources and price. As a result of the study, it was found that relative importance of attributes for the regular consumers were 48.8% price, 30.7% purchasing source, 20.5% meat type, and for non-regular consumers were 37.3% meat type, 34.3% price and 28.4% purchasing source.

4. CONCLUSION

Conjoint analysis shows the ways companies will follow in determining the preferences and demands of the producers by considering the product features in question. When asked about many features in the surveys, there are very different demands. With the help of this analysis, it can be found how important the features of the product are for the manufacturer.

Firms have to develop new products while developing existing products, or while hearing the requirements that can meet the ever-changing preferences and demands of consumers. For this reason, they have to benefit from R&D and marketing departments. While R&D departments meet the needs of manufacturers, marketing teams have to do various market researches and know the demands of the manufacturers. Although all these researches are possible with scientific studies, a certain period of research, cost and the effectiveness of the studies should reach reliable results. For this reason, studies with conjoint analysis are a very reliable guide for all sectors.

ACKNOWLEDGEMENT

This study was presented orally at the ICABGEH 20 IV International Congress on Domestic Animal Breeding, Genetics and Husbandry - 2020 İzmir, Turkey and printed as an abstract.

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•*Chapter-6*•

EVALUATION of IRRIGATION SCHEME PERFORMANCE ACCORDING to the ESTABLISHMENT YEAR

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Abstract

Irrigation management is extremely important in agriculture. Various performance indicators are used to evaluate irrigation performance. Comparisons are made with performance indicators, and suggestions for improvement are made related to this comparisons results. The maximum efficiency to be obtained from the limited resources available is of great importance for the future. Nonparametric MANOVA method was used in the research and thus performance of 123 irrigation schemes in Turkey were compared. Total 123 irrigation schemes were divided into six different groups according to the year of establishment. Financial performance indicators of the six groups formed were compared. Whether the financial performance indicators differ or not according to the age of the irrigation scheme was investigated. When the total maintenance operation and management cost per unit command area are examined, it is concluded that this value increases as the age of operation increases. It is seen that similar situation is valid for the total cost per unit command area, but this situation differs in six groups. It is seen that the total cost per unit cubic metre of irrigation water supplied decreases as the age of the enterprise increases. When the results are examined, it is seen that as the age of the enterprise increases, the total maintenance operation and management cost per unit command area also increase, while total cost per unit cubic metre of irrigation water supplied decreases.

Key words: Irrigation performance, performance indicators, nonparametric MANOVA

INTRODUCTION

The most important requirement for the continuation of life in the world is water. Besides water is the basic element of life, it is one of the main actors in combating diseases on earth and this makes it have a critical place. As water is a scarce resource in the face of increasing population, the issue of water management becomes even more important. The changing climate conditions and the ecological system and the global warming experienced in recent years necessitate a change in the perspective of water. In addition to the limited areas suitable for agriculture, occasional droughts are also one of the factors that affect the amount of products to be obtained. Water is required directly and indirectly for the food supply of humans, animals, plants and other creatures. The increasing human population and the growth in economies increase the global demand for fresh water (Hinrichsen et al., 1998; Postel, 1999; Rosegrant et al., 2002; Shiklomanov et al., 2003; United Nations Environment Programme-UNEP, 2003; Gleick, 2004). With the scarcity of fresh water and agricultural land in parallel with the increase in human population, per capita food supply has decreased by 17% in the last 20 years (Food and Agriculture Organization of the United Nations-FAO , 1961–2002). According to the report of the United Nations, the world population is estimated to reach 9.4 billion by 2050 (United Nations -UN, 2001). Increasing population will increase water use and scarcity in water will cause stress in all biodiversity and life World agriculture consumes approximately 70% of the fresh water drawn each year (United Nations Educational, Scientific and Cultural Organization -UNESCO, 2001). Only about 17% of the agricultural land is irrigated, but this irrigated land produces only 40% of the food in the world (FAO, 2002). Considering that agricultural areas use approximately 70% of fresh water and the food produced meets only 40% of human needs, it is important to keep agricultural irrigation under control and to obtain maximum performance.

The issue of water use and management in agriculture is extremely important. Researchers have also carried out many studies in this field in Turkey and the world. Some indicators have been developed for the assessment of irrigation in agriculture (Bos et al., 1994; Molden et al., 1998; Malano and Burton, 2001; Renault et al., 2007). Many studies have been conducted in the world and Turkey using these indicators. For example Arslan and Değirmenci (2018) in Kahramanmaraş, Değirmenci ve Arslan (2018) and Değirmenci et al. (2017) in Turkey, Kartal et al. (2019) in the Aegean Region, Corcoles et al. (2010) in the Castilla La manca region, Abadia et al. (2010) in the Alicante, and Alcon et al. (2017) have conducted researchs in the Spain. Zema et al (2015, 2018) have conducted studies using the performance indicators in the Calabria region of Italy. In these studies examining performance indicators, it is seen that different statistical techniques such as ANOVA and t test are used. For example, Kartal et al. (2020) used the ANOVA technique to evaluate performance indicators.

In this study, it is aimed to compare the financial irrigation performances of 123 irrigation schemes divided into six groups according to their age, using the nonparametric MANOVA method. The nonparametric MANOVA method is more advantageous than methods such as ANOVA in terms of comparing the performance more than two of more than two groups with less error at the same time and produces results with less error.

As a result of the examination, recommendations for operational maintenance are presented based on the performance age of irrigation schemes.

Material

The research was carried out in Turkey on 123 randomly selected irrigation schemes. The study was conducted over the establishment years of the selected irrigation schemes. Data on irrigation schemes were obtained from State Hydraulic Works 2017 Monitoring evaluation reports.

Method

In this study, it is aimed to compare the total the total maintenance operation and management (MOM) cost per unit command area, the total cost per unit command area and total cost per unit cubic metre of irrigation water supplied depending on the age of the irrigation unions. For this purpose, 123 irrigation schemes were selected randomly. Based on the year in which the selected 123 irrigation schemes were established, their age was calculated and accordingly the schemes were classified in 6 groups: 0-19 years are named as first group (15 schemes), 20-29 years second group (35 schemes), 30-39 years third group (22 schemes) 40-49 years the fourth group (29 schemes), 50-59 years the fifth group (14 schemes), 60 years (8 schemes) and above as the sixth group.

Research Data

In the study, the operation maintenance expenses of 123 irrigation schemes, the total MOM cost per unit command area, the total cost per unit command area and total cost per unit cubic metre of irrigation water supplied are provided by State Hydraulic Works for 2016 were used. The calculation method in Table 1 was used to calculate the performance with the selected data (Bos et al., 1994; Malano and Burton, 2001; Renault et al., 2007).

Analysis of Data

The nonparametric MANONA method was used to analyse the data in the study. MANOVA is the method used to reduce the Type I error when comparing more than one dependent variable. However, MANOVA has assumptions such as normality and independence of dependent variables. When one or more of these assumptions are not met, the nonparametric equivalent should be used. The assumption of normality and homogeneity of variances for the variables discussed in the study was not obtained. Therefore, nonparametric analysis was performed instead of MANOVA (Mertler and Vannatta, 2005), which is one of the parametric analyzes used in cases where the number of dependent variables requiring these assumptions is more than two. In this context, nonparametric MANOVA was performed using the "npmv" package (Burchett and Ellis, 2017) in the R (R Core Team, 2016) software program that provides non-parametric interpretation of multivariate data sets.

Table 1. Performance indicators and methods of calculate

	Indicators	Formul
Financial indicators	Total MOM cost per unit command area (€ ha^{-1})	$\frac{\text{(Total MOM cost)}}{\text{(Command area)}}$
	Total cost per unit command area (€ ha^{-1})	$\frac{\text{(Total expenditure)}}{\text{(Command area)}}$
	Total cost per unit cubic metre of irrigation water supplied (€ m^{-3})	$\frac{\text{(Total expenditure)}}{\text{(Total annual volume of irrigation supply)}}$

The R codes used in the research are presented in Table 2:

Table 2: Nonparametric MANOVA codes

```
## code for make npmv package active ###
>library(npmv)
## codes for calculate mean, median and variance for variables depend on group ##
>tapply(data$f1, INDEX=data$grup, FUN=mean)
>tapply(data$f1, INDEX=data$grup, FUN=median)
>tapply(data$f1, INDEX=data$grup, FUN=var)
## code for testing normality assumption with Shapiro method ##
>tapply(data$f1, INDEX=data$grup, FUN=shapiro.test)
## code for nonparametric MANOVA ##
>nonpartest(f1|f2|f3|~grup, data=data, permreps=1000, tests=c(1,1,1,1), releffects=T, plots=TRUE)
## code for compare differences of the groups ##
>ssnonpartest(f1|f2|f3~grup, data=data, test=c(1,0,0,0), alpha=.05, factors.and.variables = T)
```

FINDINGS

Under this title, firstly, the statistics of three performance indicators of the groups formed, then their findings on normality and finally, nonparametric MANOVA results are included.

Table 3: Statistics of variables depend on groups

		Groups					
		1 0-19 years	2 20-29 years	3 30-39 years	4 40-49 years	5 50-59 years	6 60+ years
The total maintenance operation and management cost per unit command area	**mean**	32.42	67.75	98.49	79.56	103.24	105.17
	median	30.12	36.55	72.03	77.96	106.02	87.09
	variance	22.51	84.13	109.66	44.32	48.51	74.16
	frequency	15	35	22	29	14	8
The total cost per unit command area	**mean**	953.03	638.89	501.19	408.65	463.86	519.32
	median	467.73	562.52	377.55	325.93	389.22	476.61
	variance	182.11	416.43	288.15	243.29	227.78	178.98
	frequency	15	35	22	29	14	8
The total cost per unit cubic metre of irrigation water supplied	**mean**	0.44	0.20	0.14	0.10	0.11	0.08
	median	0.20	0.15	0.12	0.06	0.07	0.07
	variance	0.75	0.16	0.13	0.15	0.11	0.06
	frequency	15	35	22	29	14	8

Table 3 shows the average, variance and median of each indicator in the specified groups. When the total MOM cost per unit command area are analyzed, it is seen that this value increases as the age of operation increases. It is seen that a similar situation is valid for the total cost per unit command area, but this situation differs in 6 groups. It is observed that total cost per unit cubic metre of irrigation water supplied decreases as the age of the enterprise increases.

Table 4: Findings of Shapiro Wilk's test results

	The total maintenance operation and management cost per unit command area		The total cost per unit command area		The total cost per unit cubic metre of irrigation water supplied	
Groups	**w**	**p**	**w**	**p**	**w**	**p**
1 0-19 years	0.91	0.16*	0.38	0.04*	0.52	0.00*
2 20-29 years	0.66	0.00*	0.76	0.00*	0.75	0.00*
3 30-39 years	0.62	0,00*	0.93	0.16	0.75	0.00*
4 40-49 years	0.93	0.08*	0.73	0.00*	0.39	0.00*
5 50-59 years	0.98	0,99	0.78	0.00*	0.77	0.00*
6 60 + years	0.87	0.15*	0.93	0.53	0.85	0.09

MANOVA results should be examined in order to say whether these statistics are meaningful or not. When the findings presented in Table 3 regarding the normality of the data were examined, it was concluded that the assumption of normality was not provided for many groups. For this reason, using the nonparametric MANOVA technique, it was examined whether financial indicators differ significantly in the groups formed based on the irrigation union experience.

When Table 4 is examined, it is seen that at least four out of six groups are not normally distributed in each performance indicator.

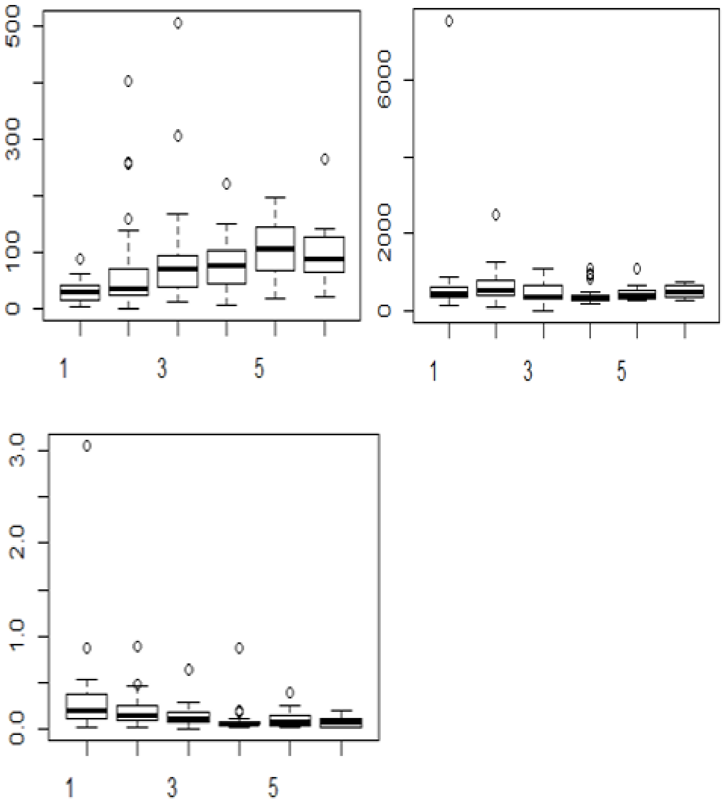

Figure 1. Box-whisker chart of performance indicators

The three box charts presented side by side in Figure 1 belong to the age groups formed of three performance indicators in financial dimension. All three graphs show that the data are not normally distributed. It was observed that the data were not statistically normal distributed both by graphical method and Shapiro Wilk's test. For this reason, the nonparametric MANOVA was used to examine whether there is a difference between groups in performance indicators.

Table 5. Findings of Nonparametric MANOVA results

	F value	sd1	sd2	p
ANOVA	4.796	12.63	225.11	0.00
Wilk's Lambda	4.29	15	317.86	0.00

When Table 5 is examined, it is seen that there is a significant difference in performance indicators between the groups F (12.63, 225.11) = 4.79, p <.05, Wilk's Λ = 4.29. Accordingly, there are differences in the age groups formed in terms of the total MOM cost per unit command area, the total cost per unit command area, and total cost per unit cubic metre of irrigation water supplied.

Table 6. MANOVA test values of groups for performances indicators

Groups	The total maintenance operation and management cost per unit command area	The total cost per unit command area	The total cost per unit cubic metre of irrigation water supplied
0-19 years	0.25	0.54	0.68
20-29 years	0.39	0.61	0.63
30-39 years	0.55	0.48	0.51
40-49 years	0.57	0.35	0.42
50-59 years	0.65	0.45	0.38
60 + years	0.69	0.56	0.33

According to the results in Table 6, it is seen that there is a difference between the groups. In

the test conducted to determine in which groups and performance indicators this difference is, it was observed that there was a difference in the values of the total MOM cost per unit command area and total cost per unit cubic metre of irrigation water supplied.

CONCLUSION

In the research, nonparametric MANONA method was used to reveal the effect of the age of

the scheme on the performance of irrigation schemes. This method selected offers the opportunity to compare the financial indicators of irrigation schemes, which are grouped by age, with low error compared to other methods with a single analysis. In this study, financial performances of the irrigation schemes were evaluated by using the data of 123 irrigation schemes. Accordingly, as the age of the enterprise increases, the total MOM cost per unit command area also increase. This increase is a significant increase of 0.05. Similarly, as the age of the enterprise increases, total cost per unit cubic metre of irrigation water supplied decreases. When the total cost per unit command area is analyzed, it is concluded that there is no difference between enterprises with 0-19 years of age and enterprises with 60 years and above, but both groups are higher than enterprises of 40-49 years. However, for total cost per unit cubic metre of irrigation water supplied, it was observed that 40-49 year old schemes were lower than schemes in other age groups. In other words, in irrigation schemes of 40-49 years, the total cost per unit command area is lower.

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•*Chapter-7*•

DETERMINING the HEAT ENERGY REQUIREMENT in GREENHOUSES AND THE EFFECTS of THERMAL SCREEN on ENERGY SAVING

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INTROUCTION

The rapid growth of the world population also increases the amount of food needed for human life. For this reason, practices that increase productivity in crop production and that can be produced throughout the year come to the fore in the world. In this context, one of the most important activities is greenhouse cultivation, which can be produced throughout the year by keeping climatic conditions under control. Greenhouses are climate-controlled plant production structures where indoor conditions can be controlled and kept in accordance with growing conditions. If year-round production is desired in greenhouses, heating should be done in the winter period (Saltuk et al., 2017). Greenhouses are important for stable food production, but require large amounts of energy to maintain their microclimates in regions with harsh climates (Kim et al., 2018). Greenhouses are high energy consuming and seasonal production facilities. In some cases, energy consumption in greenhouses accounts for 50% of the greenhouse production cost. High energy consumption has become an important factor hindering the development of greenhouses. To increase the energy efficiency of the greenhouse, it is important to estimate the energy consumption (Shen et al., 2018). The correct calculation of the amount of heat energy, which constitutes a large part of the energy used in greenhouses, is very important in terms of production.

For this purpose, revealing the heat energy required in greenhouses from hourly climate data enables to obtain healthier results (von Zabeltitz, 2011). The heat energy requirement in greenhouses is calculated according to the principles specified in DIN 4701 standards. Here, the outside temperature and the internal temperature difference are taken as basis. However, the actual temperature values occurring in greenhouses without ventilation and heating up to a certain temperature are higher than the outside temperature values. For this reason, in determining the heat requirement in greenhouses, taking into account the real temperature that occurs depending on the nature of the greenhouse and the temperature increases due to the energy storage feature of the greenhouse enables more accurate results to be obtained (Rath, 1992). In addition, conservation of energy in greenhouses heated as much as heating in greenhouses is very important due to the increasing energy prices and the CO_2 emission released by fossil energy sources into the atmosphere. Various measures are used to save heat energy in greenhouses. Tantau (2012), reported that on greenhouses with low energy requirements, determined that 80% heat savings can be achieved with the help of double-layer cover material and three-layer thermal screens. However (Baytorun et al., 2016) reported that multi-layer cover material would cause yield decreases because it reduces the light transmittance required for plant growth. For this reason, Whic are recommended the use of thermal screens rather than double-layer cover material in order to prevent heat losses from the greenhouse roof.

In the studies conducted by the researchers on thermal screens to reduce the amount of energy needed in greenhouses (Öztürk and Başçetinçelik, 2013), the effect of thermal screens made of polyethylene (PE) and polyester material on micro-air conditioning and total heat loss coefficient in plastic tunnel greenhouses was examined. It has been determined that indoor temperatures are 4.8 °C and 2.5 °C higher than the outdoor environment in polyester and PE curtain greenhouses and the curtain efficiency factor is 16% for PE curtain and 19.8% for polyester curtain. (Kim et al., 2018) The use of screens is an effective method to encourage heating savings, and using thermal screens in greenhouses at night can save 28.7% energy. For this reason, Whic are reported that thermal screens are an effective method to reduce heat conduction coefficient values by increasing thermal insulation. (Park et al., 2015) stated that a greenhouse with an aluminum multi-layer screen can save 35% in energy use compared to a greenhouse with a non-woven heat screen. (Shakir and Farhan, 2019) Three types of automatic moving screens were tested to reduce the heat loss inside the greenhouse, in their study in which a moving screen was designed to reduce the loss of greenhouse heating at winter nights in Baghdad. The results of the screens showed that for polyethylene, polypropylene and bubble films, the mean indoor air temperature during the night was 8.1 °C, 10.3 °C and 12.5 °C, respectively, and that screenless greenhouses were 5.9 °C. These results show that bubble film is more effective in saving energy than polypropylene and polyethylene films. It has been shown that the proposed different types of movable screens are strong in reducing heating losses, with heat savings reaching approximately 21.7% compared to a screenless greenhouse. (Critten and Bailey, 2002) Double and triple glazing will not only significantly reduce heat losses but also create light loss. As an alternative approach, a movable curtain can be installed in the greenhouse and pulled horizontally overnight to reduce losses. In this way, approximately 40% heat savings can be achieved. During the day, the screen can be kept open, but 4% light loss will occur in the greenhouse due to the folded material. Le Quillec et al. (2005), in a study conducted in a greenhouse where soilless agriculture tomato cultivation was carried out to determine the efficiency of the screen and to improve climate control under the screen, Whic are achieved 22%, 30% and 27% heat savings, respectively, compared to the conditions without screen. Reducing the heat required to reduce heating costs in greenhouses is possible by obtaining the energy to be used in heating in a cheap, efficient and environmentally friendly way and reducing the losses that occur during the transmission of energy. In order to reduce the heat requirement in modern greenhouses, a screen is used for heat preservation as well as structural improvements. However, since heat curtains have an important place in the greenhouse investment cost, it is very important to analyze the tightness condition and the savings rates well before making the investment in order to ensure effective savings with the thermal screen (Baytorun et al., 2019).

In the study, the required heat energy requirement was calculated by taking into account the external temperature (DIN 4701) and the actual temperature values occurring in the greenhouse based on the climatic conditions of Kırşehir, which is located in the Central Anatolia Region, Turkey. At the same time, the heat energy requirements are calculated depending on the tightness (good, medium and bad) conditions of the thermal curtains used in greenhouses and the effect of the thermal screens on heat energy saving has been revealed.

MATERIAL AND METHOD

MATERIAL

In the study, which was carried out by taking advantage of the outdoor long annual hourly temperature, solar radiation and wind speed values obtained from Kırşehir Provincial Directorate of Meteorology, the year-round constant indoor temperature in the greenhouse was 16°C and the total heat conduction coefficient for the single-layer polyethylene (PE) greenhouse was 7.0 $W/m^2 °C$ is taken. The dimensions of the greenhouse used in the calculation are given in Table 1.

Table 1. Greenhouse dimensions used in calculations

Features	Boyutlar
Compartment number	2 unit
Compartment width	8.00 m
Greenhouse length	63.00 m
Side wall height	4.00 m
Ridge height	6.10 m
Cover area	1854.05 m
Ground area	1008.0 m

METHOD

The annual heat energy required in the greenhouse depending on the hours of the year is calculated with the help of (Equation 1) (Rath, 1992).

$$Q = \sum_{n=1}^{8760} (((\vartheta_{in} - \vartheta_{ioHn} - \Delta\vartheta_{spn}) \times k'_a * A_H \times (1 - EE_{ES})) \times t_{si}) \quad (1)$$

In equality; Q: The heat energy requirement of the greenhouse (Wh), ϑ_i: The desired internal temperature in the greenhouse (°C), ϑ_{ioHn}: The actual temperature in the greenhouse without heating (°C), $\Delta_{\vartheta Spn}$: The temperature rise due to the nature of the greenhouse (°C), ka': Total heat conduction coefficient of the covering material (W/m^2°C), A_H: Cover surface area of the greenhouse (m^2), EE_{ES}: Heat saving provided by the screen (-), n: Hours of the year, t_{Si}: Time period (1 h)

The total heat conduction coefficient of the cover material is calculated with the help of Equation 2 given by Rath, (1992) depending on the cover material and the wind speed.

$$k'_a = k'_a + \frac{k'_a}{x_1} \times (x_2 \times v_w) + x_3 \quad (2)$$

In equality; v_w: Wind speed (m/s), x_1 = 7.56 (-), x_2 = 0.35 (m/s), x_3 = -1.4 (-)

In the calculations, when the screen effect is taken into account, the heat increase provided by the screen used is calculated with the help of Equation 3 if it is $ka' \leq 10$ and $EE_{ES} \leq 0.6$ (Rath, 1992).

$$EE_{ES} = \frac{EE_{ES}}{KF_{ES}} * k_a' \quad (3)$$

In equality; KF_{ES}: Correction factor depending on the impermeability of the screen, (W/m^2°C)

The correction factor (KF_{ES}) used in the calculations depending on the impermeability of the screen (Table 2) was used by taking into account the coefficient values reported by Müller (1987) and developed by Rath (1992).

Table 2. Correction factor of the thermal screen according to the insulation condition

Tightness condition of the screen	KF_{ES}(W/m^2°C)
If the thermal curtain is good insulated and tightly closed	6.8
If the thermal curtain is medium insulated and closed	11.05
If the thermal curtain is bad insulated and closed	23.43
In case of no thermal curtain	0

In order to determine the real temperature values in the greenhouse, the theoretical temperature value should be calculated (Equation 4).

$$\vartheta_{ith} = \frac{q_{GS} \times D_G \times \eta \times A_G}{k_a' \times (1 - EE_{ES}) \times A_H} + \vartheta_a \quad (4)$$

In equality; ϑ_{ith}: Theoretical temperature (°C), q_{GS}: Solar radiation (W/m^2), D_G: Permeability of cover material (%), η: Conversion factor of solar energy to heat energy (0.7), A_G: Greenhouse floor area (m^2) ϑ_a: Outdoor temperature (°C)

RESULTS AND DISCUSSION

In the study, the calculated heat energy requirements are given in Table 3 and Figure 1, in case the real temperature and temperature rise in the greenhouse are taken into consideration for different months of the year and DIN 4701. Looking at the chart, in the calculations made according to both methods, while the months when the heat energy requirement is the highest are December and January, there was no need for heat energy between July and August. According to Table 3, it was determined that there is a heat energy requirement of 518.49 (kWh/m^2year) according to the outdoor temperature values and 466.20 (kWh/m^2year) according to the temperature increase. Accordingly, it was determined that there is an average of 10.09% proportional difference between the heat requirement values calculated according to the temperature values. While this difference decreased during the cold months of the year, it was determined that it increased significantly in the months when the temperature increased.

Table 3. Required heat energy requirement according to outdoor temperature and temperature rise

Months	Heat energy requirement (kWh/m² month)		
	According to outdoor temperature values	According to the temperature rise	Proportional Difference%
January	113.90	105.49	7.38
February	86.10	79.75	7.37
March	63.79	58.00	9.08
April	33.57	29.05	13.47
May	15.78	12.26	22.30
June	3.66	1.90	48.04
July	0.04	0.00	100.00
August	0.05	0.00	100.00
September	6.60	4.10	37.84
October	29.98	24.96	16.73
November	64.23	58.04	9.63
December	100.81	92.65	8.09
Total (kWh/m² year)	**518.49**	**466.20**	**10.09**

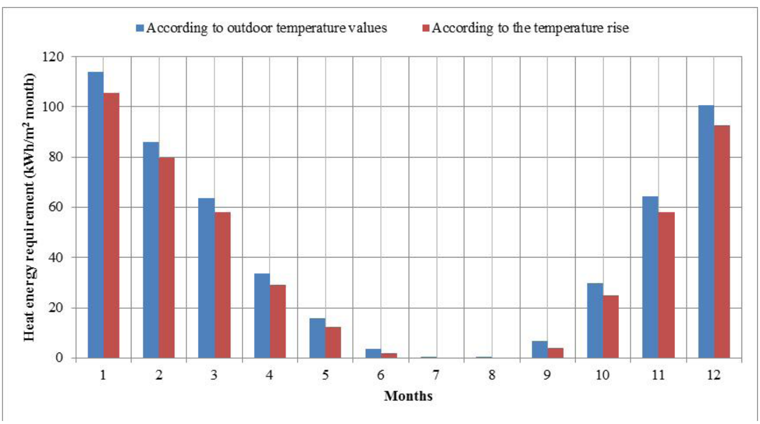

Figure 1. Monthly variation of the required heat energy requirement according to outdoor temperature and temperature rise

(Baytorun et al., 2017) calculated an average of 16% difference between the heat requirement values calculated according to the external temperature values with the calculations made according to the method in which the actual temperature and temperature rise occurring in the greenhouse. In this study, the difference between the two methods was calculated as 10.09%. Since this situation depends on the equipment features such as the floor area of the greenhouse, the cover surface area, the difference was found to be compatible with the study.

In the study, in addition to the conditions in which the real temperature and temperature rise occurring in the greenhouse are taken into account, the heat energy requirements occurring in good, medium and bad tightness conditions of the screen are given in Table 4 and Figure 2 for different months of the year. Looking at the chart, it is determined that the required heat energy is 261.46 kWh/m^2 year in case of good tightness of the thermal curtains, while this value is 333.48 kWh/m^2 year in case of medium tightness and 394.36 kWh/m^2 year in case of bad tightness.

Table 4. Heat energy requirement depending on the tightness of the thermal screen

Months	Heat energy requirement (kWh/m^2 month)		
	Good	**Medium**	**Bad**
January	58.36	74.33	87.83
February	44.39	56.78	67.26
March	32.49	41.61	49.32
April	16.54	21.12	24.98
May	7.02	8.96	10.60
June	1.09	1.40	1.67
July	0.00	0.00	0.00
August	0.00	0.00	0.00
September	2.34	3.02	3.59
October	14.45	18.40	21.73
November	33.18	42.20	49.84
December	51.59	65.66	77.56
Total (kWh/m^{2}year)	**261.46**	**333.48**	**394.36**

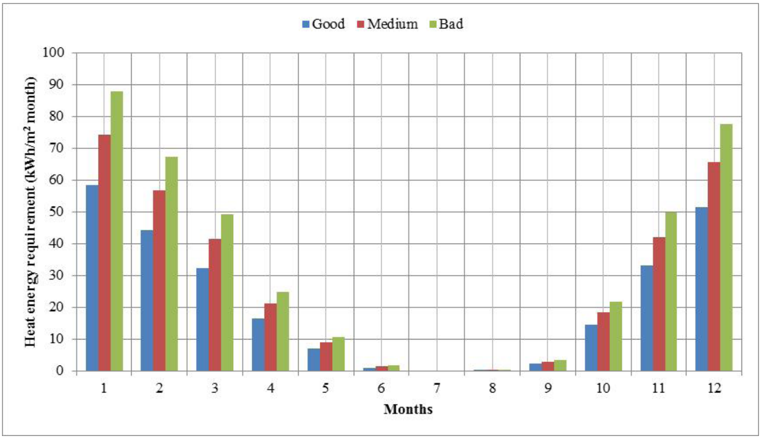

Figure 2. Monthly variation of the heat energy requirement depending on the tightness of the thermal screen

In the case of keeping the internal temperature value in the greenhouse at 16 ° C, the savings rates calculated depending on the installation of the screen with good, medium and bad tightness are given in Table 5.

Table 5. Saving rates depending on the tightness of the screen

Features	**Good**	**Medium**	**Bad**
Without thermal screen (kWh/m^2year)	466.20	466.20	466.20
Thermal screen (kWh/m^2year)	261.46	333.48	394.36
Savings rate (%)	43.92	28.47	15.41

Considering the results obtained (Table 5), energy saving rates are given comparatively. Energy saving rates obtained according to the chart, if the screen is well insulated and tightly closed (43.92%), if the screen is moderately insulated and closed (28.47%), if the screen is poorly insulated and closed (15.41%).

In greenhouses, hourly climatic values should be used in order to calculate the heat energy almost real. In addition, it is necessary to take into account the temperature increases caused by the heat energy stored in the greenhouse during the day, depending on the feature of the greenhouse. In addition, it is very important to consider the correct assembly of the screen, the material it is made of, and the density of the curtains, as in the studies of the researchers. To reduce heat loss, screens are usually pulled over the plant at sunset and lifted at sunrise. In this way, (Bailey, 1981) reported that it can reduce the heat loss by 35-60% at night, (Baytorun et al., 2017), a significant amount of energy (31%) can be saved with thermal curtains in greenhouses with good insulation, (Tantau, 1998) reported that in glass-covered greenhouses, the energy consumption during the night is approximately 70% of the total energy consumption (at indoor temperature of 15 °C), but the use of screen screens can reduce energy consumption at night. However, the energy saving rate depends on the material from which the thermal curtains are made and the weaving density. Accordingly, it has been determined that 35-40% energy savings can be achieved with traditional single-storey curtains and up to 70% in case of two-storey curtains, (Zhang et al., 1996) the curtain efficiency factor is 16% for PE curtain, 19.8% for polyester curtain, (Kim et al., 2018) using thermal curtains in greenhouses at night, 28.7%, (Park et al., 2015) 35% with different heat curtains, (Shakir and Farhan, 2019) found that different types of moving screens are successful in reducing heating losses, and about 21.7% compared to a curtainless greenhouse, (Çaylı and Akyüz, 2019) stated that screens create resistance to heat loss and reduce heat losses, and that the heat saving rates in greenhouses vary between 8% -22% at very low wind speeds and 17-36% at 4 m/s wind speed, (Critten and Bailey, 2002) about 40% with a moving screen, Le Quillec et al. (2005) stated that provide 22%, 30% and 27% heat savings from thermal screens when compared to conditions without screen. Greenhouses are agricultural structures that control indoor conditions and are one of the most important income generating branches of agriculture. Greenhouses will become more and more important in the coming years due to climate changes and increasing population (Saltuk 2019; Saltuk and Mikail, 2019). In the study, it was determined that similar to the studies conducted by the researchers, thermal screensvare effective in heat saving and a significant amount of heat saving is achieved. In greenhouse cultivation, whose importance is increasing day by day, increasing energy prices are one of the most important factors limiting greenhouse development. For this reason, it is very important to use methods such as heat curtains for energy conservation and reduce the need for heat energy in order to make an economical production by reducing the energy costs of enterprises.

CONCLUSION

The study was conducted to calculate the heat requirement in greenhouses using different methods and to determine the effects of thermal screen on energy saving. For this purpose, the heat energy requirement in the greenhouse was calculated by taking DIN 4701 and the actual temperature values in the greenhouse into consideration. As a result of the calculations made, it has been determined that if the temperature rise in the greenhouse is taken into account, the required heat energy decreases by 10.09%. At the same time, depending on the tightness (good, medium and bad) conditions of the thermal screens used in greenhouses, it was determined that the energy amount to be saved in heat energy requirements was 43.92%, 28.47% and 15.41% respectively.

In addition to correctly determining the energy requirements in the production to be made in greenhouse enterprises, conservation of this energy is extremely important in terms of reducing the share of heat energy in production costs. As a result of the study, it was determined that thermal curtains installed for energy conservation in enterprises help energy conservation, but faults during assembly will reduce the heat saving rate of the screen. For this reason, it has been concluded that the installation of screens with the help of expert personnel is extremely important in terms of energy conservation in enterprises.

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●Chapter-8●

DETERMINATION of INDOOR TEMPERATURE VALUES in GREENHOUSES ACCLIMATIZED with FORCED VENTILATION and FAN PAD SYSTEM

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INTRODUCTION

Ventilation; It is the process of replacing the air inside the greenhouse with the clean air outside in order to provide clean air in order to reduce the air temperature and relative humidity in the greenhouse and to keep the CO_2 level in the ambient air at a suitable value (Öztürk and Başçetinçelik, 2002). In greenhouses in regions where the temperature difference inside and outside the greenhouse and the wind effect are not sufficient, the expected result from the ventilation process cannot be achieved with natural ventilation. For this reason, forced ventilation applications where greenhouse air is activated by a compelling mechanism such as a fan or aspirator are needed. While greenhouse air is generally sucked in and exhausted with aspirators, the outside air is directed through the entrance openings and taken inside. Most greenhouses that are ventilated by forced ventilation also have natural ventilation windows. As the temperature inside the greenhouse increases, roof windows are opened first and if not sufficient, then side windows are opened. If the desired result is not achieved at the end of this process, natural ventilation windows are closed, the fans are turned on and forced ventilation is started (Yağcıoğlu, 2009). It is the air exchange consisting of controllable ventilation openings in the greenhouse by providing air movement towards the interior and exterior of the greenhouse with the help of fans. Today in greenhouses; Compulsory ventilation systems with ventilation fans, airflow control openings and louvered windows are widely used (Öztürk and Basçetinçelik, 2002). In order to provide adequate ventilation in greenhouses, $Z = 60^{-1/h}$ should be. In the case of an air change per minute ($Z = 60^{-1/h}$) in the greenhouse, the inside temperature is 5 ºC higher than the outside temperature. Since the temperature difference between inside and outside temperature is 5 °C, it is recommended to have an air change per minute in the greenhouse (Baytorun, 1989). As the lowest ventilation rate in greenhouses, 3/4-1 air changes per minute is generally recommended. The increase in greenhouse inside temperature is inversely proportional to the air flow. If the air change rate is 3/4 on a sunny day, the temperature increase in the greenhouse inside environment is approximately 6 ºC. However, if the air exchange rate is 1 per minute, the temperature will be about 5 °C (Öztürk and Başçetinçelik, 2002).

In order to make vegetative production in greenhouses, it is necessary to cool the greenhouses with various measures in the summer and provide a suitable greenhouse indoor environment. The mentioned environmental conditions are realized by keeping the internal temperature and relative humidity of the greenhouse between certain limits. For this purpose, the greenhouses are ventilated, cooled and shaded in the summer season (Aydıncıoğlu, 2004). In countries with a Mediterranean climate, greenhouses must be cooled to prevent plant stress and to offer quality products to the market (Hanan et al., 1978). One of the most effective solutions used today to reduce the high temperatures in the greenhouse is the use of evaporative cooling systems. Evaporative cooling simultaneously reduces the temperature and vapor pressure gap, ensuring that the greenhouse interior temperature is lower than the outside temperature (Cohen et al., 1983; Arbel et al., 1999; Willits, 2000). For this purpose, the fan-pad system used is the most effective direct humidification cooling system used in greenhouses (Al-Helal, 2001). Fan pad cooling systems, one of the cooling methods, reduce the heat load by converting the sensible heat in the air to latent heat and provide a suitable inside environment for plant growth (Mutwiwa et al., 2010). Kittas et al. (2003) have managed to keep the temperature inside the greenhouse at 28 ° C with the fan pad system. In the study, they reported that the system efficiency was 80% lower and the inside temperature value was 10 ° C lower than the outside temperature value. Whic are stated that the moisture content is important in determining the cooling efficiency with the fan pad system and that they get high performance from the fan pad system at low moisture content. (Atılgan and Öz, 2007) reported that if there is no cooling system in the greenhouses in hot regions, the temperature will rise above 38 °C and the high temperature will reduce the plant quality and the productivity of the employees. However, reported that production can be continued in greenhouses in summer by reducing the internal temperature of the greenhouses by 10-12 ºC with the fan pad system and ensuring that the greenhouse temperature drops below the outside temperature. Daives (2005) investigated the effectiveness of the fan pad system in the greenhouse where tomatoes, peppers and cucumbers were grown, and it was found that using the fan pad system, the greenhouse cools the inside temperature by 15 °C compared to the outside temperature and this system has a better cooling efficiency by 5 °C compared to other conventional cooling systems. Thus, he stated that the growing period of plants such as tomatoes and cucumbers can spread between 7-12 months.

During periods of rising temperatures, the temperature inside the greenhouse rises above the outside temperature values. Since these increased temperatures are not suitable for plant cultivation, greenhouses are left empty during these periods. However, the use of methods developed to reduce these temperatures varies depending on the climatic characteristics of the surrounding air. For this reason, it is extremely important to determine the cooling efficiency before the systems are installed. In the study, it was aimed to determine the temperature values that can be reached in the greenhouse with different numbers of air changes and fan pad system by using compulsory (mechanical) ventilation when temperatures are not suitable for plant growing and the suitability of these values for plant growing.

MATERIAL AND METHOD

MATERIAL

In the study, the dimensions of the greenhouse covered with a single layer polyethylene plastic (PE) are given in Table 1.

Table 1. Greenhouse dimensions used in calculations

Dimensional features of the greenhouse	Dimensions
Compartment number	4 units
Compartment width	8.00 m
Greenhouse length	60.00 m
Side wall height	4.00 m
Ridge height	6.10 m
Cover area	3068.15 m
Floor area	1920.0 m
Greenhouse volume	103638.0 m

METHOD

In the study, with the help of energy balance in greenhouses, the temperature difference reached depending on the desired number of air changes in the greenhouse was calculated by using Equation 1 (von Zabeltitz, 2011).

$$\Delta T = \frac{\tau * I_O * (1 - E_V * f)}{V_A * c_p * \rho + u * (A_C / A_G)} \quad (1)$$

In equality; ΔT: Inside-outside temperature difference (^{o}C), τ: Permeability of the cover material (0.6), I_o: Outside solar radiation (W/m^2), Ev: The ratio of solar radiation reaching the greenhouse used in transpiration (greenhouse with floor area fully covered with plants: 0.9), f: Vegetation factor (for vegetables: 0.8), VA: air exchange number corresponding to unit area (m^3/m^2/ h), cp:

specific heat of air (Wh/kg°C), ρ: density of air (kg/m^3), u: Cover material heat transmission coefficient (W/m^2°C), A_C: Cover material surface area (m^2), A_G: Greenhouse floor area (m^2)

In the study, the air volume changed per hour depending on the greenhouse volume and the number of air changes corresponding to the unit area are 0 (no air changes), 10 (54 m^3/m^2/h), 20 (108 m^3/m^2/h), 30 (162 m^3/m^2/h), 40 (216 m^3/m^2/h), 50 (270 m^3/m^2/h), 60 (324 m^3/m^2/h), it was used in calculations as.

The temperature values that can be reached in the greenhouse with evaporative cooling (Baytorun and Makauy, 2019) were calculated with the help of the equations reported. According to this;

The temperature value to be reached at the exit of the pads in evaporative cooling is calculated from Equation 1.

$$\theta_L^* = \theta - \eta * (\theta - \theta_{FK}) \qquad (2)$$

In equality; θ: is dry bulb temperature at pad outlet (°C), η: is pad efficiency (%), θ_{FK}: is wet bulb temperature (°C).

The temperature value reached depending on the final enthalpy value and moisture content of the air in the greenhouse was determined by Equation 3.

$$\theta_i = \frac{h_i - x_i * r_o}{c_{pL} + c_{pw} * x_i} \qquad (3)$$

In equality; h_i: Enthalpy value of the air entering the greenhouse at constant enthalpy value, x_i: Moisture content of the air entering the greenhouse by humidifying at constant enthalpy value (kJ/kg), r_o: Heat of evaporation (kJ/kg), c_{pL}: Specific heat of air (kJ/kg°C), c_{pw}: Specific heat of water vapor (kJ/kg°C)

RESULTS AND DISCUSSION

During summer periods, high temperature values that are being formed in greenhouses can greatly influence the efficiency of production workers and also decrease the productivity of plants grown there Oz et al., (2009). Plants grown in the greenhouse have adapted to average temperatures of 17-27 °C (von Zabeltitz, 2011). Considering the tomato plant, which is the most cultivated plant product in our country, Abak and Çürük, (1995) reported that the temperature at which the tomato plant grows best is 17-27 °C. At the same time if the temperature drops below 13 °C and rises above 30 °C, plant growth, pollen formation, pollen vitality and germination ability are decrease. Vural et al., (2000) At temperatures above 30 °C, plant development continues, flowering occurs, but pollen germination deteriorates, even if the pollen tube occurs, it cannot grow sufficiently and the flower falls because fertilization does not occur. With the occurrence of parthenocarpic small fruits, the yield decreases. For this reason, it is extremely important to choose the most accurate method in order to keep the temperature inside the greenhouse under constant control and reduce it in terms of the yield and quality of the plant to be grown.

Th temperature difference reached depending on the number of air changes in an unshaded greenhouse where vegetal production is carried out is given in Figure 1. As can be seen in the figure, in the case where the outside solar radiation is 900 W/m^2 in the greenhouse where vegetative production is carried out, the temperature difference reached according to the number of air changes is 1.3-13.5 °C. In conditions where the outside solar radiation is 750 W/m^2, the temperature difference reached according to the number of air changes is 1.0-11.3 °C. Here, it has been shown that while increasing outside solar radiation increases the temperature difference between inside and outside of the greenhouse, the increasing number of air changes decreases.

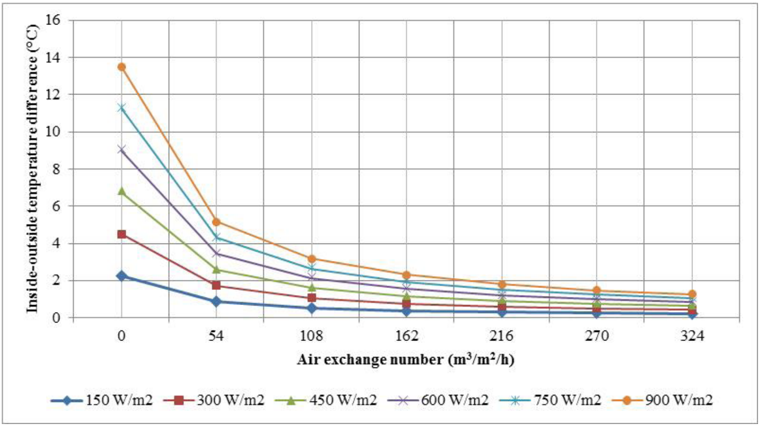

Figure 1. Temperature difference reached depending on the number of solar radiation and air changes in the unshaded greenhouse

If the solar radiation reaching the greenhouse is partially prevented, the decrease in the temperature that occurs in the greenhouse decreases depending on the radiation reaching the greenhouse (Baytorun and Makauy, 2019). The temperature values reached in the greenhouse interior environment at different air change numbers and solar radiation values are given in Table 1. Table 1 shows the internal temperature values that will occur in the greenhouse if the external temperature is 30 °C, the solar radiation is 900 W/m^2 and the radiation coming into the greenhouse is shaded with 50% shading net. Accordingly, it has been observed that when the outside temperature is 30 °C, the interior temperature values cannot be reduced below 27 °C in all values of the number of air changes, even by shading.

Table 1. Temperature values reached in the greenhouse environment at different air exchange numbers and solar radiation values

Air exchange number ($m^3/m^2/h$)	Solar radiation	
	50% shading net (450 W/m^2)	No shading (900 W/m^2)
0	36.8	43.5
54	32.6	35.2
108	31.6	33.2
162	31.2	32.3
216	30.9	31.8
270	30.7	31.5
324	30.6	31.3

The temperature values reached at different air change numbers in the greenhouse with unshaded (900 W/m^2) and 50% shading net (450 W/m^2) are given in Figure 2.

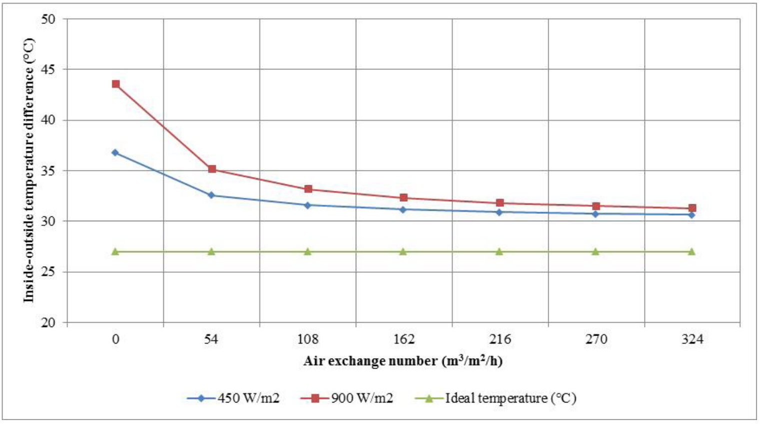

Figure 2. Temperature difference reached in the shaded greenhouse depending on the solar radiation and the number of air changes

As can be seen from Figure 2, the temperature difference reached according to the number of air changes in the shaded greenhouse where vegetative production is carried out can be reduced between 2.24-15.40%. However, it is seen that these decreasing temperatures are not sufficient for plant production.

Solar radiation entering the greenhouse from the cover material is the main source of heat gain in greenhouses. The purpose of shading is to reduce the air temperature in the greenhouse by preventing undesirable sunlight from entering the greenhouse. In studies conducted for this purpose, Shukla et al. (2008) decreased 5 °C, Bailey (1981), 6 °C, Sethi and Gupta (2004) 3-4 °C. Abdel-Ghany et al. (2012) stated that the shading material does not reduce the temperature more than 5 °C in greenhouses and this temperature drop is insufficient in regions where the temperature is above 45 °C in summer, and stated that this material needs to be developed. In the study, it was determined that with the increasing number of air changes, the inside-outside temperature difference changed between 0.6-6.8 °C. It has been seen that these results are among the values given by the researchers. However, it is important for plant production to check whether the internal temperature values that decrease in high outside temperatures are suitable for plant breeding. In this case, it is necessary to cool the greenhouse temperatures with one of the evaporative cooling methods.

In evaporative cooling in greenhouses, the temperature values at the exit of the pad vary depending on the air exchange coefficient corresponding to the unit area, solar radiation and the efficiency of the pad used in the system (Baytorun and Makauy, 2019). Also, Kittas et al. (2003) reported that the shading net made from the top helps to reduce the internal temperatures in the fan pad cooling system. Xu et al. (2015), in their studies of evaporative cooling and external shading, when the pad and external shading were done together, the inside temperature was kept 2-3 °C lower than the outside temperature and the relative humidity was kept at 80% due to the shading preventing solar radiation reaching the greenhouse. Boyacı and Akyüz (2019a) determined in their study that shading net reduces the rate of solar radiation reaching the inside environment, therefore it gives more positive results in reducing inside temperatures and increasing the relative humidity, so it would be more suitable to use with cooling pads. In Table 2, the temperature values that can be reached at the pad outlet depending on the different outside temperature and relative humidity values are given. In this calculations, where the number of air changes corresponding to the unit area is 216 $m^3/m^2/h$, the solar radiation is reduced to 450 W/m^2 by shading and the pad efficiency is 90%. As can be seen from the chart, it has been observed that when the outside temperature is 30 °C and 32 °C, the temperature value reached in the greenhouse inside environment allows plant breeding. In addition, considering the increasing temperature values and relative humidity values, it was seen that the greenhouse inside temperature values exceeded 27 °C and did not provide the optimum temperature values required for plant breeding.

Table 2. Temperature values that can be reached in the greenhouse depending on outside temperature and relative humidity

Relative humidity %	Outside temperature (°C)					
	30	32	34	36	38	40
	Achievable temperature values in the greenhouse (°C)					
10%	16.5	17.9	19.3	20.7	22.1	23.5
20%	18.5	20.0	21.5	23.0	24.4	25.9
30%	20.6	22.2	23.7	25.3	26.9	28.4
40%	22.7	24.4	26.0	27.7	29.3	31.0
50%	24.9	26.6	28.4	30.1	31.9	33.6

Under conditions where solar radiation is 450 W/m^2 by shading, pad efficiency is 90% and the air exchange coefficient corresponding to the unit area is 216 m^3/m^2/h, the temperature values reached in the greenhouse depending on the different outside temperature and relative humidity values are given in Figure 3.

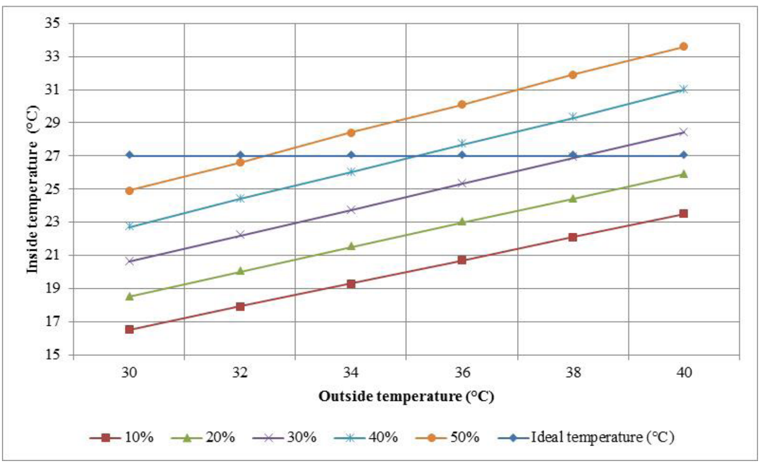

Figure 3. Accessible temperature in the greenhouse depending on the outside temperature and relative humidity

As can be seen from the figure, in conditions where the temperature inside the greenhouse is 34 °C, the permissible outside air humidity should be at most 45% in order to keep the greenhouse temperature at 27 °C in the greenhouse. If the air humidity is above 45%, it is seen that the temperature that can be reached in the greenhouse will increase to 28.4 °C.

The temperature values reached in the greenhouse depending on the relative humidity of the outside air are given in Figure 4. It is given here that the air exchange coefficient is 216 $m^3/m^2/h$, solar radiation is reduced by 50% (450W/m^2), the outside temperature is 40 °C and the pad efficiency is 90% and 70%.

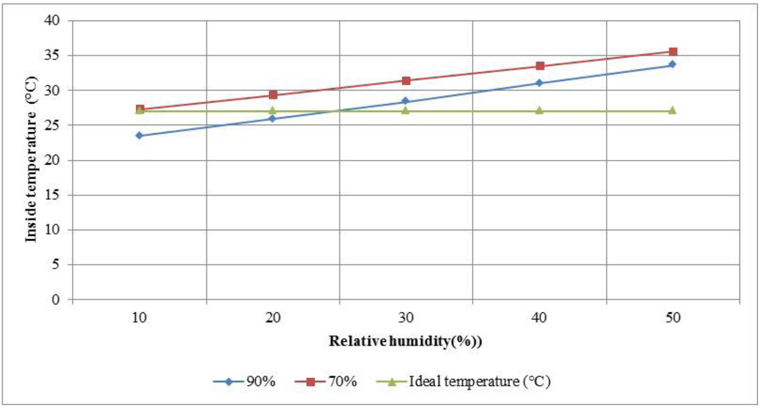

Figure 4. Accessible temperature values depending on pad efficiency and outside humidity

As can be seen from the figure, in case the pad efficiency is 90% and the outside temperature is 40 ° C, the outside relative humidity value should not be more than 24% in order to keep the temperature in the greenhouse at 27 °C. On the other hand, when the pad efficiency is 70%, the external relative humidity value should not be higher than 10%. The relationship between the increasing relative humidity in the greenhouse and the difference between outside and inside temperature is given in Table 3. Looking at the chart, it is determined that if the outside temperature is 40 °C and the relative humidity is 10%, the greenhouse interior environment is 16.5 °C lower than the outside environment, while the inside temperature is 6.4 °C lower than the outside environment when the relative humidity is 50%.

Table 3. Relation between increasing relative humidity and outside-inside temperature difference in a greenhouse

Relative humidity %	Outside Temperature (°C)					
	30	32	34	36	38	40
	Outside-Inside temperature values in the greenhouse (°C)					
10%	13.5	14.1	14.7	15.3	15.9	16.5
20%	11.5	12.0	12.5	13.0	13.6	14.1
30%	9.4	9.8	10.3	10.7	11.1	11.6
40%	7.3	7.6	8.0	8.3	8.7	9.0
50%	5.1	5.4	5.6	5.9	6.1	6.4

In the study, the difference in external and internal temperatures reached depending on the external relative humidity is given in Figure 5. With the increase in external relative humidity, the difference in temperature between outside and inside started to decrease.

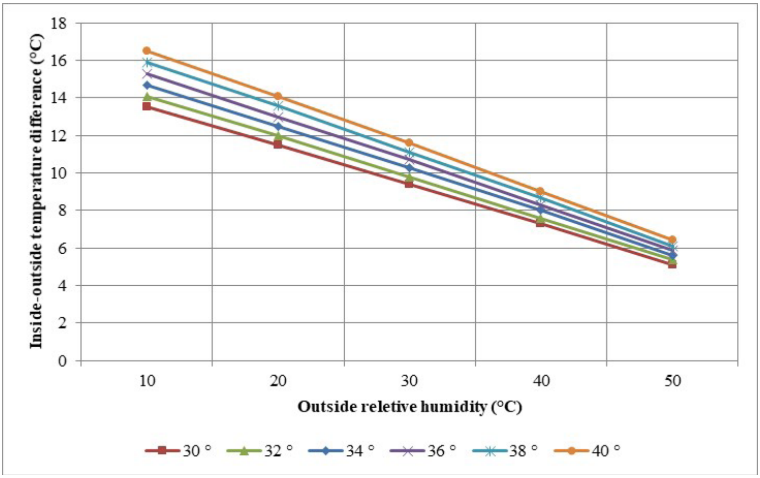

Figure 5. Inside-outside temperature difference reached in the greenhouse depending on the external relative humidity

Looking at Figure 5, it is seen that the internal temperature increases in the relative humidity values and the inside environment suitable for plant breeding cannot be provided. Therefore, it is seen from the figure that it is necessary to pay attention to the relative humidity values in the regions where evaporative cooling is applied.

Kittas et al. (2003), in their study using the fan-pad system, found the inside temperature value 10 °C lower than the outside temperature value. (Davies, 2005; Fuchs et al., 2006) found it 15 ºC lower. Erbil and Atılgan, (2014), in their studies to prevent excessive temperature increase in the greenhouse during the summer season, a humidified cooling system was used to reduce the air temperature entering the greenhouse and to prevent plant water stress by increasing the relative humidity value. It has been determined that especially in hot climatic regions such as Antalya, the inside temperature can be cooled to 7-14 °C with the fan-pad system. Öz and Atılgan, (2015) stated that in the fan pad system, when compared to low relative humidity, if the external relative humidity is high, the inside temperature value will be 6-7 °C higher and the outside relative humidity will affect the system performance. Boyacı and Akyüz (2018) reported that while the outside temperature is around 40 °C, the temperature inside the greenhouse is not suitable for plant growth, and the fan pad system has reduced the internal temperature to 15 °C and the greenhouse internal temperature is kept at appropriate ranges for plant growth. At the same time, reported that increasing relative humidity values in the outside environment decreased system efficiency and internal temperature values increased. Boyacı (2019b) found the system efficiency to be 73% with the fan-pad cooling system, and the highest value of the outside-inside temperature difference to 12.85 °C. As a result of the study, it was determined that the latent heat transfer inside the greenhouse is higher than the sensible heat transfer due to the evaporation effect of the fan-pad cooling system used in the greenhouse during periods of rising temperatures, and it has been determined that the inside temperature values are suitable for plant breeding.

Considering the studies conducted, it was seen that the temperature values reached in the greenhouse at different temperatures and relative humidity were obtained similar to the studies of the researchers. It has been determined that the relative humidity value is very important in achieving these results and the increasing relative humidity increases the temperature values reached in the inside environment; therefore, attention should be paid to the relative humidity values of the ambient air in the greenhouses where fan pads will be installed.

CONCLUSION

In periods when high temperatures in the greenhouse do not allow plant cultivation, reducing the internal temperature values with different methods is extremely important in terms of quality and efficiency in greenhouse cultivation. As a result of the study, the internal temperature values of the compulsory (mechanical) ventilation and fan pad methods that can be reached in the greenhouse environment and the effectiveness of the methods in the case of shading were determined. In the study, it was determined that the increased solar radiation in the outside environment increases the greenhouse interior temperatures and the increasing number of air changes helps to reduce the inside temperatures. However, these decreasing temperature values remained insufficient in some periods depending on the outside temperature values. It has been determined that the fan pad cooling method used in this case gives more successful results than the forced ventilation method, and the use of this method with shading net contributes to the fan pad system in reducing interior temperatures. In addition, it has been concluded that the increasing relative humidity in the areas where the fan pad system will be installed will decrease the reached temperature values.

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●Chapter-9●

EFFECTS OF PROBIOTIC BACTERIA ON PLANTS

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ABSTRACT

In parallel with the increasing food demand in the world and in Turkey, the use of high-yielding varieties and species has brought along discussions on the protection of soil fertility.Increasing use of chemical fertilizers with industrialization causes irreparable damages on the environment and soil.Some alternative searches for reducing this damage emerged during this period.One of these searches is microorganisms living in the soil with plants.The effects of these organisms that have been living with plants and animals since the existence of the world have always been a matter of curiosity.The protection of these structures is absolutely necessary for the continuation and protection of living life.Many of these microorganisms live in common with plants in the soil.The full understanding of this process has been a matter of curiosity today.These structures in soil microbiology have many benefits from plant nutrient intake to soil micro flora.Discussions on these concepts have led to the emergence of the concept of "probiotic bacteria".Especially the negative effects of chemical fertilizers on the soil and the environment revealed the importance of these bacteria.It manifests itself in the form of clusters in the soil close to the plant roots zone by reducing the effects that cause the reduction of soil pollution.After these effects were understood, giving the plants by inoculation caused increases in yield and quality.Today, colonized structures consisting of probiotic bacteria have emerged as a new concept with the name of bio-fertilizers.Although these fertilizers are environmentally friendly, their being sustainable in parallel with the decrease in input prices causes their use to increase rapidly.In this study, the importance and place of probiotic bacteria in plant development are emphasized.

Keywords: Probiotic, biofertilizer, rhizobium, mycorrhiza.

1. INTRODUCTION

Agricultural activities carried out in parallel with the increase in the world population caused an increase in the use of fertilizers and pesticides. These fertilizers and medicines adversely affect many living systems on macro and micro scale. It causes especially pollution of underground and surface water resources (Küçük, 2019). While the world is trying to meet the nutrient needs of the increasing population, it also turns towards friendly systems and practices that protect the environment (Araus et al., 2014). These microorganisms play an important positive role in the ecosystem.It is important in the nitrogen and carbon cycle in the formation of different ecosystems.They also have similar roles in soil formation. There are millions of living colonies at macro and micro level in the soil.It has an important place in terms of sustainable agriculture and access to healthy food. (Garcia-Fraile et al., 2012).It has numerous benefits such as regulating nutrients for soil and plants. They help to reduce fertilizer and medicine costs, which are an important input in agricultural production.The people who first introduced this concept are two scientists named Has and Kel(Has and Keel, 2004).The mechanisms of action of these organisms are as follows;

1- Efficiency and competitiveness in rizosphere colonization,

2- Creating induced systemic (ISR) resistance in their hosts,

3- Direct antagonistic feature on pathogens

Soil microbiology has a significant impact on plant fertility.Elements that plants need such as C, N, P, S, And, Mg; It is transformed into a useful form for microorganisms at the end of various decomposition and synthesis processes.Microorganisms actually create such processes while providing their own nutritional and energy requirements. Plants that grow in the soil also use these products that they create unconsciously. Bacteria have an important function in this process. The ways of interaction with the plant differ.The first of these interactions is generally free-living bacteria, and they benefit from the metabolites they release into the root zone.The second is endophytes that live in the plant and use their metabolism for the benefit of the host (Küçük, 2019). One of these endophytes is a gram-negative soil bacteria type that binds nitrogen. Rizobium enters an ensymbiotic relationship with parasponia and roots of legumes. Bacteria colonize in plant roots as root nodules.In these nodules, nitrogen in the air is converted to ammonia, and this ammonia supplies the plant with organic compounds such as glutamine and ureaides. The plant, on the other hand, provides the bacteria with organic compounds it obtains from photosynthesis. This mutalistic beneficial relationship applies to all rhizobium species.

Another probiotic bacteria is mycorrhizae. The word means mushroom-root (mykes-rhiza) in Greek (Palta et al., 2010). It was first used in 1885 by a German forest pathologist to describe the fungal-tree symbiont. After this date, it was learned that many plants on earth had a symbiotic partnership with fungi.It is estimated that 95% of the plant species on earth form partnerships with mycorrhizae.In the excavations carried out by archaeologists, it was determined that this partnership dates back to 400 million years ago (Dura, 2010). In general, mycorrhiza spores are in parallel with the demands of the plants they live with symbiotically.Infection occurs as a result of spore hyphae of mycorrhiza fungi joining with the roots of the host plant. Spore formation occurs as a result of this situation. There are 10-20 thousand spores in 1 kg of soil depending on the plant type and density.Certain criteria must be under suitable conditions for mycorrhiza spores to survive. For example, according to many studies, it was stated that the optimum temperature should be 30 °C for mycorrhiza spores to survive (Schenck and Schroder, 1991). Apart from this, it was stated that the activity of mycorrhiza spores decreased at low and high temperatures, and it was determined that the relationship between mycorrhiza and temperature differed between regions (Bagyaraj, 1982). Mycorrhiza mushroom; They are useful soil microorganisms found naturally in nature and form their own root extensions by adhering to plant roots.Thus, it acts like a true extension of the root system that lives with the plant.Plants take root and enter the places where the roots cannot enter and reach and ensure that the plant nutrients and water contained therein can be better absorbed by the plant.Thus, it provides an increase in production and efficiency. In this period when global warming and climate changes are on the agenda, it is important to use less fertilizer and water.This situation is of great importance both for our country's economy and for our country and our world environmentally (Alkaraki, 2000).

These probiotic bacteria have recently been conceptually named as biofertilizers. It is stated that it significantly increases plant and soil fertility.Significant increases were obtained when applied to the plant in certain formulations prepared for this purpose(Bhattacharyya and Jha,2012). These bacteria transform plant nutrients that are not in the form that the plant can take in the soil into useful forms that they can take(Malua and Vassilev,2014). In addition, it provides many benefits to the plant by reducing pathogenic disease sources by eliminating stress sources by performing phyto hormone biosynthesis.In this study, the effects of plant probiotic bacteria on plant yield and yield components were briefly examined.

2. PLANT PROBIOTIC BACTERIA

It is a huge family of bacteria that promote plant growth. These bacteria generally contribute to the growth and development of plants in different ways.Generally, they synthesize the material directly assimilated to the plants or provide benefits by transporting plant nutrients or by providing resistance against diseases-pests (Çakmakcı, 2004).

2.1. Azospirillum*spp.*

It is one of the important bacteria involved in nitrogen fixation in wheat (Figure-1).Baldani*et al.* (1987) caused increases on yield between 15.8-31% in a study conducted.In another study conducted under controlled greenhouse conditions in wheat, biomass, grain, protein and N increase were detected in the plant (Saubidet*et al.*, 2002). In another similar study, yield increase was achieved by -12.1-31.7%, 16-128% and 4.9-15.5% in millet, mustard and paddy, respectively(Kloepper*et al.*, 1989). In a study conducted on corn, an increase in the amount of dry matter and Mg was found (Hernandez *et al.*,1997). Ribaudo*et al*. (2001), on the other hand, glutamate synthesis, dehydrogenase activity and N increase in root and leaf were detected in maize under greenhouse conditions.Bacteria of the genus *Azospirillum* generally constitute the group associated with grains in temperate regions. It has increased plant yield in some legumes and sugar canes. (Santi et al.,2013; Maksimow et al., 2011).Some isolates of *Azotobacter* have been tested as biofertilizers for various grains such as wheat, barley, oats, rice and maize.Their efficacy has also been determined in other plant species such as sunflower, tomato, beet, tobacco, tea, coffee and coconut.*Azospirillumbrasilense*type bacteria, on the other hand, in the greenhouse under controlled conditions, especially the dry matter ratio, leaf area, root number and length 33-40% and hydraulic permeability rate increased by 25-40% (Sarig, 1998; Sarig, 1992). Vedder-Weiss *et al.* (1999) in a study conducted in the climate chamber in beans, increases in root and stem wet weight were found.In a similar study, there was an average increase of 25% in the yields of sorghum, wheat, barley, corn and oat plants.In addition, significant increases were detected in root and stem wet weights of plants(Dobbelaere et al., 2001). In another study conducted on chickpeas and broad beans, an increase in root and stem wet weights occurred(Hamaoui et al., 2001).In another study conducted by Okon and L-Gonzalez (1994), *A.lipoferum* and *A.barasilense* species on corn and wheat have been reported to cause increases in yield in appropriate humidity and environment.It has been reported that bacteria of the *A.lipoferum* type have positive effects on the first emergence and development in sunflower germination(Fages and Arsac, 1991). It helped create a strong root system in corn (Jacoud et al., 1998). *A. brasilense*has been reported to cause yield increases in wheat (Caceres et al., 1996*).A. chroococcum*type bacteria have detected increases in the amount of nitrogen available and plant biome in the cockscomb plant(Pandey et al., 1999).

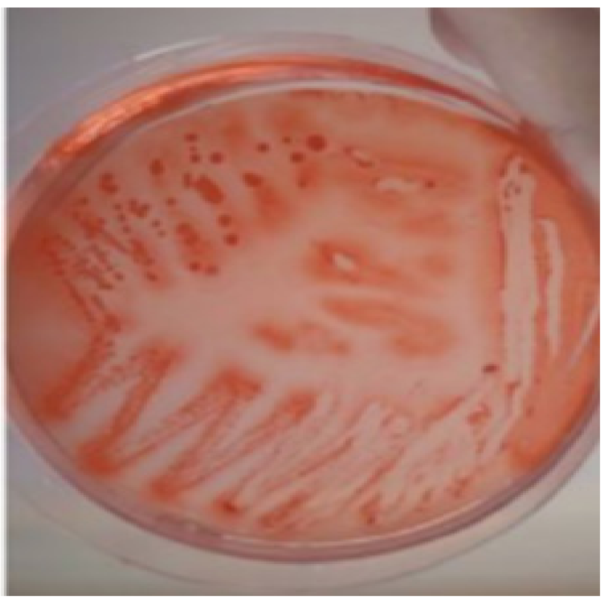

Figure-1: Azospirillum*spp.*

2.2. Bacillus *spp.*

Phosphate, potassium and zinc solvent species are involved in this bacterial colonization (Figure-2).It is also stated that they have a role in the realization of some biological events. It has been reported that it contributes by producing auxin in plants such as potatoes and rice (Sokolova et al., 2011). Some members of the *Bacillus* genus have been identified as producers of the cytokine (Sokolova et al., 2011).It has been determined that *Bacillus megaterium* and *Azotobacterchroococcum* strains produce cytokine and support cucumber growth.They also found that thuja seedlings inoculated with cytokinin-producing *Bacillussubtilis* strains were resistant to drought stress (Sokolova et al., 2011). It has been stated that bacteria of the *Bacillus subtilis* species increase the yield in peanuts by 37% by protecting them from heat and drought stress (Turner and Backman, 1991).The same bacterial species caused an increase in 12-94% dry stem weight and 13-100% root weight in onion (Reddy and Rahe, 1989).There are various bacterial colonies that dissolve potassium. The most important ones among these are *Bacillus* and *paenibacillus*genera.It has been found that *Bacillus edaphicus*increases potassium intake in wheat (Sangeethet al., 2012).*Bacillus mucilaginosus*-yield has a higher yield in potassium-infused Sudanese weed. Chlorophyll content and plant biomass increased in the leaves of wheat and corn plants inoculated with the K solvent *Bacillus mucilaginosus* under laboratory conditions.It has been stated that *Bacillus polymyxa* bacteria are effective on the growth of peanuts (*Arachishypogaea*) and nutrient intake from the soil under high temperature and salty stress conditions (El Akhal et al., 2012). The same bacteria caused an increase in yield in wheat (Caceres-et al., 1989).It has been stated that *Bacillus* bacteria keep many pathogens under control where high selenium concentrations in the soil.Gram (-) and gram (+) bacteria have produced antibiotics active against pathogenic fungi (Maksimow et al., 2011). The same researcher was effective in controlling *Bacillus cereus* UW85 type bacteria in clover root rot.This bacterial species caused an increase of 9% biomass in lettuce and tomato plants under greenhouse conditions (Hoffmann-Hergartenet al., 1989). Two strains of *Bacillus subtilis* in soybean seeds have a positive effect on plant growth and can produce antibiotics against various pathogens (Araujo et al., 2005).In particular, hydrolytic enzymes such as cellulase, chitinase and beta-glucanase have been reported to play an important role in the biocontrol of pathogens. Because cellulose, chitin and β-glucan are the main components of the fungal cell wall.Chitinase and-gluconase secreting bacteria prevented fungal growth.In another study, they reported that a siderophore producing strain defined as *Bacillus subtilis* against Fusarium wilt established biological control and supported pepper growth (Yu Xet al., 2011).It has been stated that some *Bacillus* species reduce root rot caused by *Rhizoctoniabataticola* significantly(Sharmaet al., 2017).Under field conditions, *B.amyliquefaciens*, *B. pumilis, B. subtilis, B. cereus* bacteria species increased plant growth such as leaf area, root and stem wet dry weight, fruit yield, and decreased nematode damage in tomato and pepper plants(Kokalis-Burellaet al., 2002).Çakmakcı et al. (1999), in a study carried out separately on sugar beet and barley under greenhouse and field conditions, *B.polymyxa* increased root weight of 7.5-16.5% in sugar beet and 8.4-18.2% in grain yield in barley.

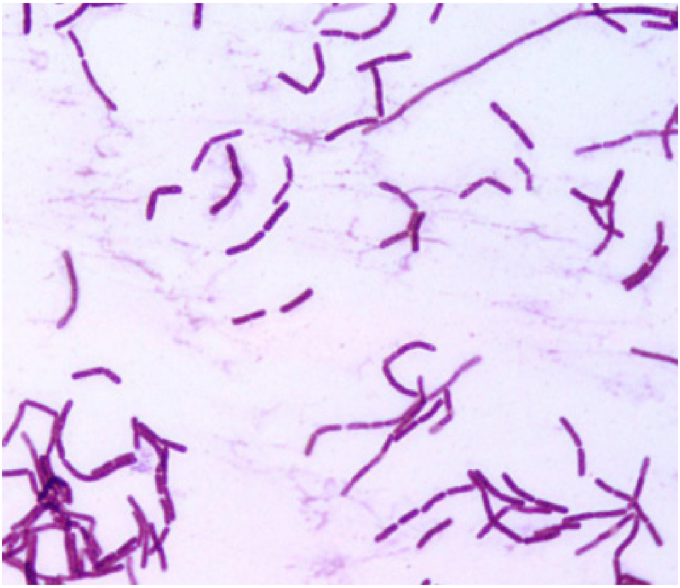

Figure-2: Bacillus *spp.*

2.3.Pseudomonas *spp.*

Such bacteria produce the ACC deaminase enzyme (Glick, 2014: Figure 3).By balancing the NPK levels of 2 strains of *Pseudomonas* containing this enzyme, it caused increases in yield and quality, especially in wheat (Shaharoona et al., 2008).In a similar study, they reported that Pseudomonas strains played an effective role in the growth of wheat seedlings (MagnuckaandPietr, 2015). In a study conducted by Zerrouk et al. (2016), it was reported that the development of a *Pseudomonas* strain isolated from the palm rhizosphere was not affected under both salt and aluminum stress, and that it encouraged the plant to grow under two different stresses as a result of inoculation with corn plants.*P.cepacia, P.fluorescens, P.putida*in the climate chamber, in their study with winter wheat, an increase in grain yield of 46-75% was obtained (De Freitas and Germida, 1992).It was determined that *P. chlororaphis* caused an increase of 6-8% in germination rates in winter wheat(Krop et al., 1996).*P. fluorescens*and *P. corrugata*bacteria species provide 12% increase in fruit yield and 18% increase in biomass (McCullaugh et al., 1996). It was stated that*P.fluorescens*bacteria species created 5.6-9.4% yield increase in the study conducted in the greenhouse (Gagne et al., 1993).*P. corgatta*increased the efficiency of N use in coke plant and increased the yield (Pandey et al., 1999).*P. fluorescens causes* increase in leaf area and plant stem diameter in *B. pumilus* blueberries (De Silva et al., 2000).

In a similar study, the development of dicotyledon root plants increased in the climate chamber with *P. putida* Canola, lettuce, tomato, barley, wheat, oat plants (Hall et al., 1996).*P. syringae*causesprotein increase in beans (Alstrom, 1995). *Pseudomonas spp.* root and stem wet weight in plants such as canola, potato, sugar beet, rice, corn, wheat and barley cause increases in tuber yield (Suslow and Schroth, 1982; Iswandi et al., 1987).

Figure-3: Pseudomonas *spp***.**

2.4.Clostridium *spp.*

In a study conducted on beet, barley, wheat and radish, their effects on germination, stem length and yield increase were determined (Polyanskayaet.al., 2000).*Beijerinckiamobilis*species have a similar effect (Figure-4).

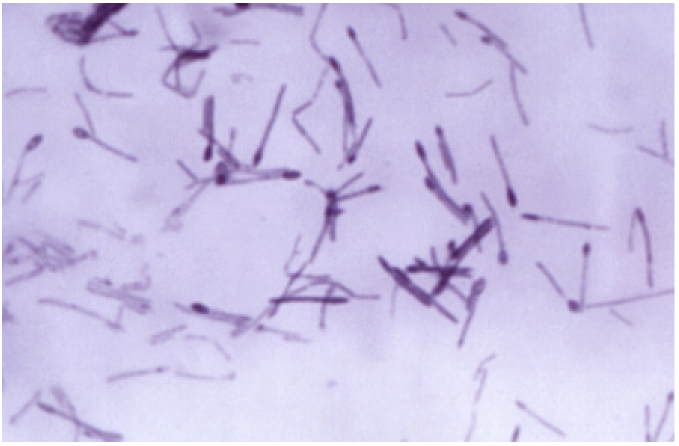

Figure-4: Clostridium *spp.*

2.5. X maltophilia

In a study conducted in a greenhouse, it was found that sunflower has positive effects on the first emergence and germination and seedling development (Fages and arsac, 1991).

2.6. Serratiaplymuthica and S. liquefaciens

In a study of cucumber in field conditions, 12% fruit count resulted in increases in 18% fruit weight (McCullaugh et al., 1996).

2.7.Variovorax*spp.* and Phyllo Bacterium *spp.*

In a study carried out in a climate chamber in canola plant, an increase in dry weight of 11-52% was produced (Bertrand et al., 2001).

3. CONCLUSION

Humanity has faced serious problems due to the depletion of the limited resources used by the increasing world population to produce the nutrients it needs.In addition to sustainable agricultural practices, new environmentally friendly alternatives are required by reducing the use of chemical fertilizers and pesticides to overcome these problems.Access to healthy food in modern agricultural practices will only be possible with the use of macro and micro-level organisms in the soil.In addition to its positive effects on soil and environment, it also has positive effects on yield and quality.They will contribute significantly to reducing the damage of pH, salt, heavy and toxic substances in the soil.It is beginning to be understood that these probiotic organisms are an important turning point in access to healthy food in terms of human and environmental health.Whit these purpose all stakeholders need to come together and carry out joint studies and research on this issue.

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