CURRICULUM

GROWING FRUIT, VEGETABLES AND ORNAMENTAL PLANT IN GEOTHERMAL GREENHOUSES

“Developing Adult Skills in the Field of Geothermal Energy”

Erasmus+ KA204, Strategic Partnerships for Adult Education Project

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INTRODUCTION

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Dear Trainee,

The increasing population of the world causes an increase in the need for food. At the same time, many factors such as the use of agricultural areas as a structure due to the expansion of settlements due to the increasing population, the presence of unproductive agricultural areas have led humanity to fruit and vegetable cultivation with alternative methods.

At the beginning of these methods, greenhouse cultivation draws attention. With greenhouse cultivation, more efficient and quality products can be obtained per unit area.

With the modernization of greenhouse activities with the developing technology, soilless farming practices are used in places where the soil is unsuitable, and fruit and vegetable cultivation is carried out in almost every season. Likewise, the use of geothermal resources for heating greenhouses enables greenhouse activities to be carried out in cold regions.

The use of geothermal resources is less costly than other fuels. However, while it is among the advantages of being environmentally friendly and renewable energy, the operating investment cost is high.

With this module, adults; It was formed from the researches and data obtained on the cultivation of fruit, vegetables and ornamental plants with geothermal energy.

The use of geothermal energy as a resource is important in terms of both protecting nature and contributing to the economy in meeting the increasing needs with the increasing population.

1.GREENHOUSE AGRICULTURE

1.1.Importance and Definition of Greenhouse

With the increasing population, the soil, which is the most important retention factor of the rural area, is fragmented, causing the formation of small agricultural areas. Small agricultural areas increase the cost and decrease the yield. However, if these agricultural areas are converted into greenhouses, it becomes possible to obtain high yields. Again, greenhouses are of great importance in ensuring the constant need for food due to the increasing population.

Greenhouse is a covered structure made by using light-transmitting materials such as glass, plastic, fiberglass, in which environmental conditions can be controlled or regulated in order to provide suitable conditions for the cultivation of plants. Greenhouse as another definition;
They are covered structures where vegetables and flowers are grown economically all year long, regardless of climate. To make a more comprehensive definition, by keeping the climatic conditions, factors such as temperature, light, humidity, and air under control, it is possible to produce different cultivars and their seeds, seedlings and saplings throughout the year, to protect the plants, to display them such as glass, plastic, fiberglass. It is a high system greenhouse cultivation structure made in different ways by covering with material. The businesses where these facilities are located are defined as greenhouse businesses.

However, plastic mulches, superficial covers, pillows, low and high tunnels that partially destroy the negative effects of environmental conditions cannot be qualified as greenhouses.

Picture 1-2: Greenhouse

The fact that greenhouses provide high efficiency from small agricultural areas, can grow a wide variety of products in every season regardless of climatic conditions, provide economic cultivation, prevent unplanned urbanization by preventing migration from rural areas to cities, and create job potential in rural areas increase their importance in our country and in the world.

The benefits of greenhouse cultivation can be listed as follows;

- The growing period of plants is extended. It provides more than one plant production opportunity during the year.
- Greenhouse products do not have market problems. It is always available in the market.
- Unit yield and quality of plants grown in greenhouses increase.
- Seasonal work is out of the question for workers due to working throughout the year.
- Technological developments are utilized in greenhouse cultivation and accordingly it contributes to the development of technology branches.
- Provides regular income opportunities for adults engaged in greenhouse activities.

1.2.Plant Cultivation in Greenhouses in the World

Greenhouse applications started with growing vegetables by covering the pits opened on the southern slopes with a transparent material in Italy during the Romans period, and then continued to develop with glass covering the south-facing facades of the houses in Europe. These structures, which were built in the 16th and 17th centuries, can be considered as the beginning of greenhouse applications. In the 18th century, the number of windows was increased and their directions were changed in order to solve the problem of insufficient light in these buildings. Later on, greenhouse cultivation started to develop rapidly with the developing industry in the USA and Europe.

Looking at the international greenhouse cultivation today, it is seen that greenhouses are spread over a wide area around the world. It is seen that ecological factors and greenhouse technology are quite different on this wide spreading area.

1.2.1.Greenhouse Applications According to Climate Zones

Greenhouse activities are spread over an area of approximately 1.2 million hectares in the world. This spread can be done using different methods depending on climatic conditions. Different greenhouse applications appear as environmental factors and technological application differences. As a result; It is possible to group them as cool, temperate and both climates.

The temperate zone, including Turkey, is the most suitable climatic zone for greenhouse applications. While cooling systems are needed in very hot climates, heating systems are needed for greenhouse activities in the cool climate zone. This increases the cost in greenhouse applications. In the map below, the red areas show the hot areas and the blue areas show the cool areas and form an idea for greenhouse application areas.

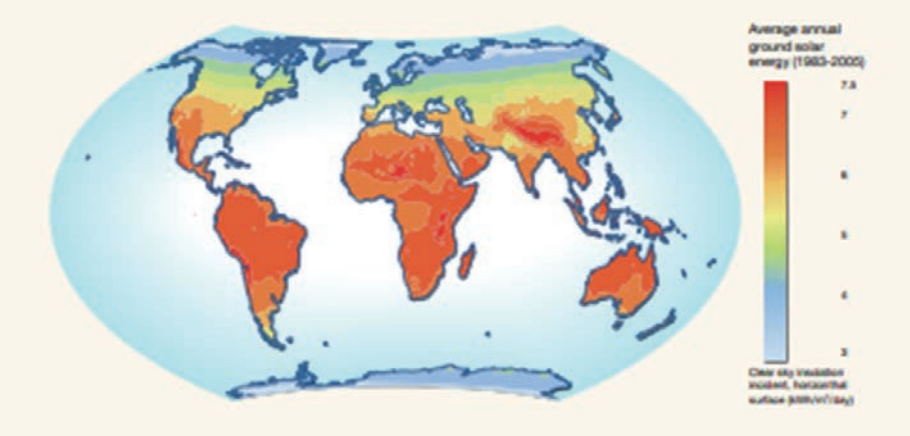


Figure 1: World Solar Energy Map

1.2.2.Countries in the Cool Climate Zone

The main countries in the cool climate zone with an average annual temperature below 10 °C are the Netherlands, England, Denmark, Germany, Romania, Bulgaria and Russia. The Netherlands is the leading country among these countries with its 10,000 hectare glass greenhouse area and production technique. The common features of these countries in terms of greenhouse cultivation are as follows;

- Greenhouse building materials are made of profile steel, aluminum or other alloys, while covering materials are glass.
- Greenhouse construction and installation of heating systems increase the investment cost.
- It is necessary to make continuous heating systems inside the greenhouse due to climatic conditions.
- Appropriate heating, lighting, ventilation and other cultural processes are carried out in these greenhouses.

Compared to the countries in the cool climate zone, the countries in the temperate climate; It encounters difficulties such as higher production costs, higher energy costs, and increasing the product variety.

1.2.3.Countries in the Temperate Climate Zone

Spain, France, Japan, Turkey, Italy, Greece and Israel are countries in the temperate climate zone with an annual average of 10 oC to 20 oC. Favorable environmental conditions in these countries make greenhouse activities more profitable. The high average temperature in winter months reduces greenhouse heating costs and an increase in greenhouse areas is observed in these countries.

Considering the common features of the countries in this belt;

- The greenhouse cover material used is plastic.
- Greenhouse operation investment cost is low.
- Greenhouse heating costs can be kept at the lowest level.
- In these countries, greenhouse activities can be carried out mostly as spring and autumn firstfruits.
- Despite the low investment and operating costs, the low level of production technologies in greenhouses reduces the yield and quality obtained from greenhouses.

1.2.4. Countries with Two Climates

The main countries in two climatic zones with annual average temperatures between 0 °C and 20 °C are the Netherlands, Egypt, Morocco, Italy, Spain, Belgium and China. The common feature in these countries is glass and plastic greenhouses together. While greenhouses in Mediterranean countries have these features, high technology is also applied in plastic greenhouses in the USA and Japan.

Due to the increase in the cost of greenhouse heating all over the world, greenhouse management is shifting from cold regions to temperate regions, and towards regions where the season is suitable and heating costs are low in winter. For this reason, the most suitable countries for greenhouse businesses are those at 30-40 latitudes. While the temperature increases below the 30th latitude, the need for cooling becomes the heating need due to the decrease in air temperature above the 40th latitude.

1.3. Analysis of Greenhouse Activities by Country

When greenhouse cultivation experiences are examined in cities around the world, from Spain's white-roofed city Almeria to tomato paradise Florida, no matter which country one goes to, the potential to satisfy the consumer with the quality of the products produced in modern greenhouses and the producers with their earnings is always high. Greenhouse cultivation, which is applied in large agricultural areas, especially in countries with difficult climatic conditions, gives strength to the agricultural sector. More precisely, with modern greenhouse cultivation, it is possible to grow bananas in Iceland and tomatoes in Canada.

1.3.1. Greenhouse Planting in Spain

It is the first country that comes to mind when it comes to greenhouse cultivation. Spain, the largest greenhouse country in Europe, is Turkey's biggest rival in this regard. 43 thousand hectares of a total area of 52 thousand hectares is in the city of Almeria, which is located in the south of Spain and known as the city with the white roof. In Spain, 80% of greenhouse areas are reserved for vegetables, 15% for fruit and the remaining 5% for seedling cultivation. The main products produced are tomatoes, peppers, cucumbers, green beans, melons and watermelons.

While Almeria, the white-roofed city of the country, had barren lands until about 25 years ago, today it has literally turned into a greenhouse paradise with imported soils, hydroponic systems, drip irrigation and chemical fertilizers.

Picture 3: A Bird's-Eye View of the Greenhouses in Almeria (The City with the White Roof)

1.3.2. Greenhouse Planting in China

It is difficult to talk about a country that has more area than China in greenhouse distribution in the world. Being the world leader in vegetable production, China also uses its surface area advantage in greenhouse cultivation. Most of the greenhouse cultivation of 2.7 thousand hectares is carried out in the northern regions of the country.

1.3.3. Greenhouse Planting in the Netherlands

The Netherlands, located in the cool climate zone, is confronted with 10 thousand hectares of glass greenhouse areas and advanced production techniques. Half of the country's total fresh fruit and vegetable production is met by greenhouse cultivation. While greenhouse products are mainly produced with pepper, tomato and cucumber, approximately 80% of these products are exported.

1.3.4. Greenhouse Planting in the USA

Glass greenhouses are mostly found in the USA. Mainly tomato cultivation is done. The average yield of tomatoes per hectare is 484 tons. The regions where greenhouse cultivation is most common are Florida and California, depending on climatic characteristics.

In Canada, which has arable lands only in the south of the country, 89% of production is provided by greenhouse cultivation. Due to the harsh weather conditions, the majority of plant cultivation is in the form of greenhouse cultivation. In Canada, where tomato production is less than in the USA and Mexico, more greenhouse applications are encountered for tomato cultivation.

1.3.5. Greenhouse Planting in Italy

Italy, which has a say in the greenhouse race in the Mediterranean, produces plants with 30 thousand hectares of greenhouse cultivation. The most commonly grown greenhouse product is tomato. However, the fact that the lands are too divided in Italy affects the greenhouse activities negatively. Half of the greenhouses are located on lands smaller than 5 hectares, while 10% of them are built on areas of 50 hectares and above.

1.4. Greenhouse Plant Cultivation in Turkey

Commercial greenhouse activities in our country are located in Yalova in the last years of the Ottoman Empire and the first years of the Republic Period. While greenhouses were established for research purposes in the 1940s, a small number of commercial greenhouses were established in Antalya and İzmir between the years 1940-1960. After 1970, greenhouse cultivation has shown great improvement with the use of transparent plastic (polyethylene) as a covering material. In our country, along the coasts of the Mediterranean and Marmara regions, citizens practice greenhouse activities as a source of livelihood.

There is a great deal of parallelism between the domestic distribution of greenhouse areas in Turkey and the temperature distribution. So much so that the most greenhouse activities in Turkey (excluding the provinces where geothermal greenhouse cultivation is carried out) are concentrated in the southern provinces.

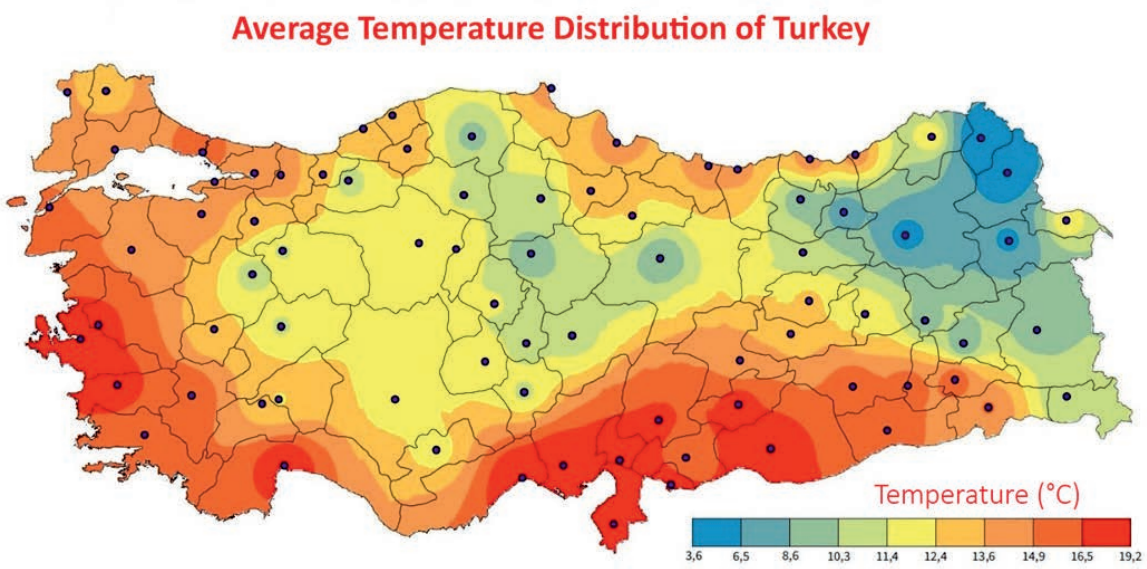


Figure 2: Annual Average Temperature Distribution of Turkey

With the use of geothermal energy as an alternative energy source in recent years, greenhouse cultivation has started to develop in the inner regions as well. Geothermal greenhouse activities are found in Denizli, Manisa, İzmir, Afyon, Balıkesir, Kütahya, Aydın and Urfa provinces.

Greenhouse activities have developed over time compared to the past, with the change of building materials, the advancement of technology and the evaluation of alternative resources.

The most important factor in greenhouse cultivation is to provide the desired temperature in the greenhouse. Heating applications to reach the desired temperature increase the cost. Accordingly, greenhouse cultivation has not developed in some regions due to the very cold winter months. In this case, geothermal energy and greenhouse activities have come to the fore as an alternative source.

Turkey is in the most suitable position in terms of greenhouse cultivation in the world. It has the advantage of climate that many countries do not have. In these regions, by using passive systems with solar energy, it is possible to grow crops in economical and practical greenhouses in a short time in spring and autumn, and to obtain early crops, that is, at the beginning of the season, with appropriate and sufficient spraying without the need for hormone use.

In our country, greenhouse applications and plant cultivation meet the 8-month vegetable need between October and July, while providing export opportunities. It has become a sector that has a business line for thousands of adults.

The biggest factor limiting greenhouse management in our country is the high fuel used to provide the optimum temperature for plant growth in the greenhouse, as well as the heating system and maintenance costs. Mediterranean, Aegean, Marmara and Black Sea Regions are regions with suitable microclimates for greenhouse management.

The registered greenhouses in our country are given in the table below according to 2019 data.

Greenhouse Type	Number of Businesses	Number of Greenhouses	Area
Glass greenhouse	10.060	19.720	26.353
Glass and Plastic Greenhouse	2.744	3.875	9.070
Plastic greenhouse	40.409	81.106	246.890
High tunnel	2.179	6.936	18.995
Low Tunnel	1.668	5.201	126.367
Overall total	57.060	116.838	427.675

Table 1: Number of Greenhouses and Distribution Area by Greenhouse Types in Turkey

It is possible to list the general characteristics of greenhouse cultivation in Turkey as follows;

- Benefiting from ecology due to the presence of microclimate areas
- Developing near major markets
- Cultivation of early-season products
- Greenhousing as small family businesses
- Glass and plastic greenhouses are common.

The distribution of greenhouse products grown in Turkey is as follows, according to 2019 data.

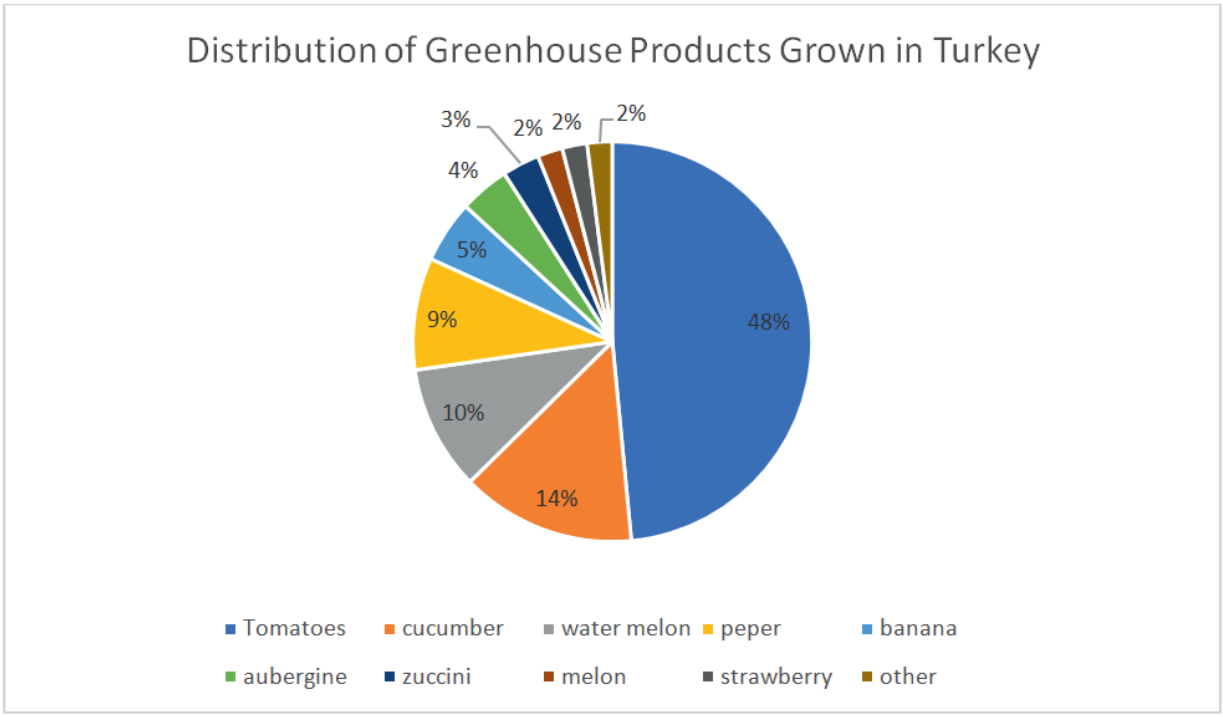


Figure 3: Distribution of Greenhouse Products Grown in Turkey

1.5. Factors Influencing the Selection of the Greenhouse Location

1.5.1. Ecological Factors

Plants need suitable environmental conditions for their development. Therefore, when planning a greenhouse, a suitable environment should be prepared for the plant to be grown.

1.5.1.1. Light

Light has an important place in the development of green plants. Plants take advantage of sunlight while performing photosynthesis. Plants convert the carbon dioxide in the air into carbohydrates by combining them with the water in their content only when there is light. In this way, while providing the food it needs, they also release oxygen for the continuation of life. In order for the plants to develop, the sunbathing level must be at the desired level in the region to be grown.

The amount of sun exposure of each plant during development is different. As the amount of sun exposure increases, plant growth also increases. The choice of greenhouse location is important, especially considering that the weather is constantly cloudy during the winter months. Our country allows the construction of greenhouses almost everywhere in terms of sunbathing.

1.5.1.2. Temperature

The ambient temperature is very important in determining the greenhouse temperature. Preferring places where the winter months are warm for greenhouse construction reduces heating costs. In cold seasons, greenhouses need to be heated, especially at night. In addition, micro-climate places are suitable areas for setting up greenhouses. The temperature needs of greenhouse plants are also different from each other. Therefore, before installing the greenhouse, it is necessary to know the temperature requirement of the plant to be grown.

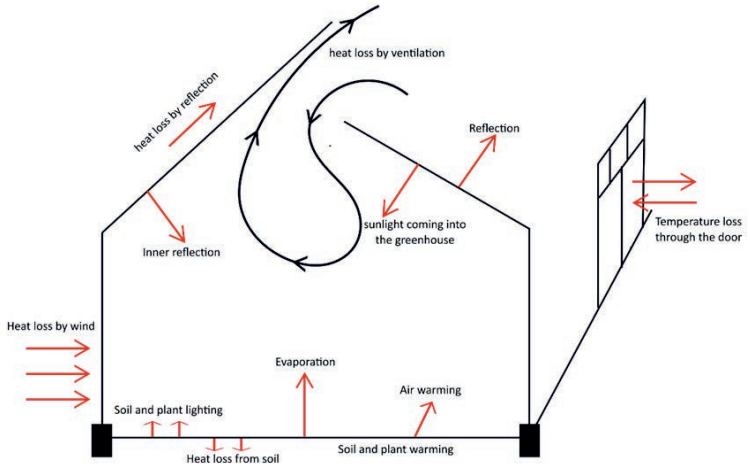


Figure 4: Environmental Factors in Planning the Greenhouse Type

Vegetable	Day °C	Night °C		Cut Flower	Day °C	Night °C
Tomato	19-24	14-18		Dianthus	12-15	7-10
Aubergine	25-30	18-19		Lilium	18-20	13-15
Pepper	21-27	15-19		Gladiol	16-20	10-12
Cucumber	22-24	16-18		Chrysanthemum	18-21	12-13
Melon	20-25	16-18		Gerbera	20-22	10-12
Beans	22-26	12-16		Rose	21-23	15-16

Table 2: Optimal Temperature Requirements of Some Vegetables and Cut Flowers Grown in Greenhouses

1.5.1.3. Air Movement

Local winds should be known in the places where greenhouses will be established. In places where greenhouses will be established, places that are sheltered from cold and strong wind should be preferred. If a greenhouse is required to be installed in a windy area, windbreaks should be built to protect it from the wind. The wind can cause destruction on the greenhouses and damage to the cover material. Wind can also affect the indoor temperature of the greenhouse in various ways, no matter how well the covering material is covered.

1.5.1.4. Soil and Topography

Greenhouses have an important place among the places where agriculture is made, so for a quality agriculture, care should be taken to ensure that the soil is of good quality. If the plant is to be grown in pots, the quality of the greenhouse soil is not important. When greenhouses are established in places with high ground water, problems such as coldness of the soil, lack of air and disease of plant roots are encountered.

In the area where the greenhouse will be established, the topography is also important besides the greenhouse soil. The very slope of the area where the greenhouse will be installed can make it difficult to install, water and cultivate the soil.

1.5.1.5. Direction

The right direction should be chosen to ensure maximum sun exposure in greenhouses. In countries located in the northern hemisphere, the greenhouse is oriented to the south, southeast and southwest. The southward slope of the slope prevents the effects of cold and strong winds. While determining the greenhouse direction, the plants to be cultivated should be planted in a south-north direction so that they do not shade each other.

1.5.2. Irrigation Water

Water is needed to meet the plant's water needs, to moisten or cool the greenhouse on hot days. Apart from this, water is needed for washing the harvested dirty vegetables and fruits before the market, diluting the drugs to be used, and washing the greenhouse cover when necessary. If there is no water in the areas where the greenhouse will be established, rainwater collection areas can be created to meet the water need, and the water need can be met.

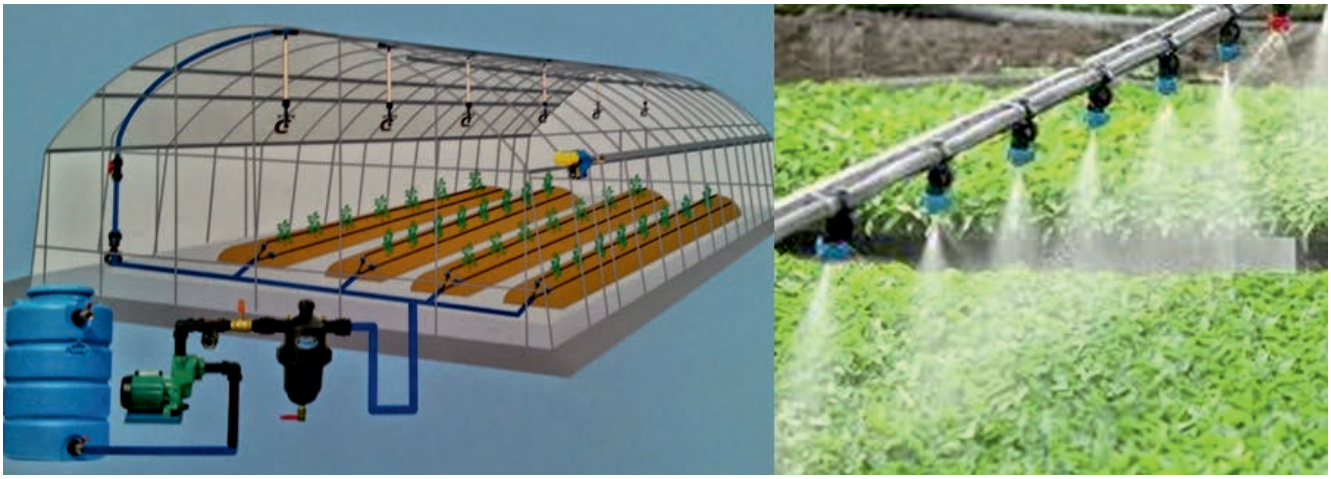


Figure 4.5: Examples of Irrigation System Applied in Greenhouses

1.5.3. Economic Factors

Greenhouse farming, which has job opportunities for adults, has become a sector in geographies suitable for greenhouse establishment. In order to achieve investment goals such as high quality and low cost, the following issues should be considered in the selection of greenhouse location; energy, road, market and sales opportunities, location of the enterprise.

•**Energy;** It is used for heating the greenhouse and operating tools and equipment. It should be permanent and inexpensive. Energy sources; electricity, geothermal energy, solar energy, coal, natural gas, heating fuels.

•**Path;** greenhouses should be close to the road. In this way;

1. Produced products are not damaged until they reach the market
2. It allows the greenhouse materials to be transported to the greenhouse more easily.

•**Market and sales opportunities;** Crops grown in greenhouses are generally more expensive. The goal of the breeders is to sell the products at high prices in a short time. Therefore, the establishment of greenhouses close to large settlements is considered an advantage. However, if the desired demand cannot be reached in the domestic market, foreign market searches should also be made.

•**Business layout;** There are other structures inside the enterprise, apart from the greenhouses. These are storage, packaging, fertilizer preparation, sterilization and heating areas. In order for the maintenance and controls of the greenhouse to be carried out immediately, these sections must be in a certain order.

2. GREENHOUSE TYPES AND BUILDING MATERIALS

2.1. Greenhouse Types

Plants show efficient growth and development under suitable environmental conditions. Greenhouses are planned for plant cultivation in case suitable conditions cannot be provided.

It is necessary to create the most suitable conditions in the selection and planning of greenhouse types. Factors such as the purpose of use, size, climatic conditions, operating cost are important in the selection of the greenhouse type.

Picture 6: Plant Growing in Glass Greenhouses

2.1.1. Purpose of Use of the Greenhouse

We can list the usage purposes of greenhouses as follows;

- To provide economic benefit,
- Making use of free time,
- Research,
- To be able to grow various plants,
- To train

Especially the greenhouses established for economic purposes provide additional income opportunities to family businesses or families. While those that are established as the main source of income are usually large, those who want to earn ancillary income build smaller greenhouses.

2.1.2. Size Required in the Greenhouse

The size of each greenhouse section or the total greenhouse area in a greenhouse business depends on the amount and type of labor in the business. If there are tools and equipment to be used in the enterprise, the greenhouses are larger and the number of units should be planned more. For a small family business, it is desirable that the greenhouse to be established should not be less than 500-600 m2. Greenhouses planned for side income are dependent on the amount of time available for greenhouse work and the amount of labor in the family.

2.1.3. Climatic Conditions of the Settlement

In the selection of the greenhouse type, various factors such as the highest and lowest temperature values of a region, wind condition, precipitation type, intensity and duration, sunshine, number of cloudy days and latitude should be considered. For example, the roof of the greenhouse located in a cold and snowy region should be more durable and low, and it should be made higher in warm places.

2.1.4. Topographic and Ecological Characteristics of the Greenhouse Site

Environmental conditions such as the topography of the place where the greenhouse is planned, land slope, microclimate conditions, being in a closed or open valley are taken into consideration.

2.1.5. Financial Strength of the Business

The economic power of the enterprise and the large amount of capital allocated for the greenhouse are important in the selection of the greenhouse type to be established. For businesses with sufficient capital for glass-covered, aluminum-framed greenhouses, the initial setup cost is high, while maintenance costs are low throughout the year. On the other hand, the annual maintenance costs of the plastic-covered and wood-framed greenhouse types, which have low initial investment costs, are high.

2.1.6. Tool and Equipment Opportunities of the Business

While the work is mostly done by hand in small greenhouses, tools and equipment are used for processes such as soil processing, fertilization, spraying, soil disinfection and product cleaning in large greenhouse enterprises.

2.1.7. Future Changes and Developments

Before the greenhouse is installed, the installation should be planned according to the product to be grown. If it is planned to grow another product other than the one grown in the future, it will be necessary to change the greenhouses. For example; A tall plant cannot be grown later in a low greenhouse in order to grow low plants. For this reason, before the greenhouse is established, the products that can be grown should be evaluated and a joint planning should be made accordingly.

Picture 7: Modern Greenhouse Built with Developing Technology

There are many variables in agriculture such as developing technology, changing climatic conditions, demanded products. By adapting to these variables, the product target at average standards is preserved.

2.1.8. Owner's Likes

The general culture of the adults who will establish the business, the knowledge they have about agriculture, their aesthetic views and their experience about greenhouses in different geographies are effective in determining the greenhouse type. In our country, mostly environmental greenhouse types are taken as an example in determining the greenhouse type.

If a general evaluation is to be made, the following should be taken into account when establishing a greenhouse suitable for the selected greenhouse type.

- Greenhouses should be aesthetically pleasing with other structures in the enterprise.
- The greenhouse should be able to provide the most suitable environmental conditions for plant growth, health and yield.
- The planned location and size of the greenhouse installation should be in accordance with the future goals of the enterprise.
- In order to benefit from the workforce in the most efficient way, greenhouse sections and parts should be designed in the most appropriate way.
- Greenhouse building materials should be strong, durable and pleasant in appearance.

2.2. Classification of Greenhouses

2.2.1. Greenhouse Types by Size

Greenhouse size: is the width and length of the greenhouse floor area. The product of these two dimensions gives us the base area. When giving the size of a greenhouse, the length and width should be in harmony with each other. Instead of building narrow and short greenhouses side by side, a large greenhouse with the same floor area can be established to prevent the negative effects of environmental conditions. It also saves on initial setup cost and fuel.

According to the size of the greenhouses; It is divided into three as large, medium and small greenhouses. Large greenhouses can be in the form of individual or block greenhouses. Large greenhouses are greenhouse types with a floor area of more than 1,000 m2 and a height of 50-100 m. Medium-sized greenhouses vary in size between 100-1000 m2. These greenhouses, which are between 25-50 m in length and 3-20 m in width, are used for aquaculture and seedling production. Small greenhouses are greenhouses with a floor area of less than 100 m2. The widths of these greenhouses, which are used especially for floriculture in home gardens, vary between 1-6 m and their lengths between 2-20 m.

2.2.2.Greenhouse Types According to Establishment Types

According to the way greenhouses are established; It is divided into four as individual (single roof), block, adjacent and tower type greenhouses.

Individual greenhouses are set up alone. Adjacent greenhouses are set up against a wall or building. In these greenhouses, even if one or more surfaces are surrounded by walls, the slope of the roof faces south and transparent material is used. Block greenhouses are formed by combining more than one individual greenhouse. In the absence of walls at the joints, there are struts to carry the weight of the roof. If the side walls are removed when combining individual greenhouses, they are called "undivided block greenhouses", if the side walls are not removed, these greenhouses are called "split block greenhouses".

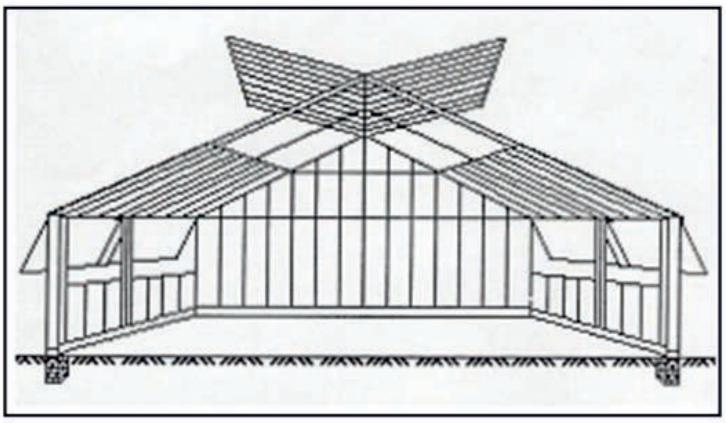


Figure 5: Example of Individual Greenhouse Architecture

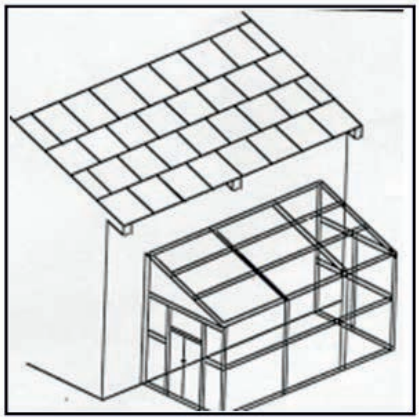


Figure 6: Example of Adjacent Greenhouse Architecture

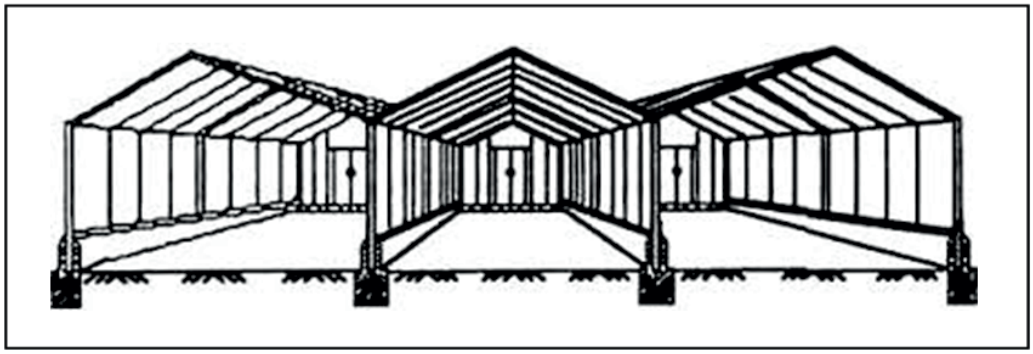


Figure 7: Architectural Example of Block Greenhouses

Tower type greenhouses are established from small production areas in order to create more production areas. Examples of this type of greenhouse are found in Western European countries. In tower greenhouses, the production area can be increased with a rack system connected to a gear arrangement.

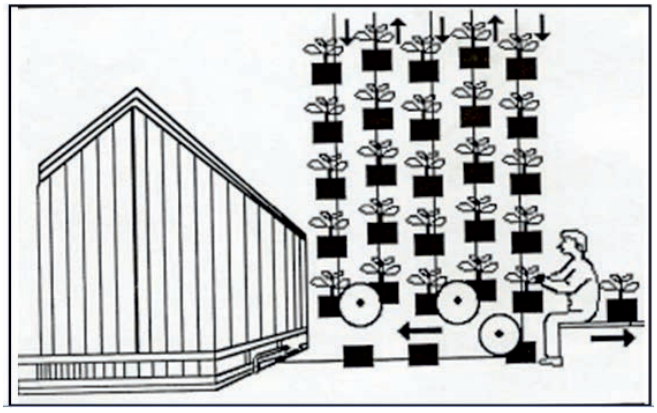


Figure 8: Architectural Example of Tower Type Greenhouse

2.2.3. Greenhouse Types According to the Structure

The most important structural elements that make up the framework of the building are the beam and the roof carrier column. Greenhouses with these elements are planned according to the roof shapes. Greenhouses with a double pitched roof are grouped according to the roof carrier column (support). Thus, this type of greenhouses can have two, three, five or more supports.

Since the roof beam is carried by two columns from both ends in double-supported double-sloped greenhouses, labor is more comfortable compared to greenhouses with more supports. The greenhouse interior can be arranged as desired.

Picture 8: Venlo Type Glass Greenhouse

In many countries around the world, greenhouses differ according to their skeletal structures. For example; Venlo type greenhouses, examples of which we come across in the Netherlands, are known as the lightest structure, and the ventilation process in these greenhouses is done by opening the glass windows. If this type of ventilation is not sufficient in regions with a continental climate where the wind is less, new systems can be developed to provide ventilation.

Picture 9: Greenhouse Frame with Steel as the Construction

Greenhouses also vary according to the type of skeletal material. Greenhouses with wooden, iron, concrete, aluminum, artificial fiber skeletons and air-inflated greenhouses are used.

2.2.4. Greenhouses by Temperature

Greenhouses according to the temperature;

- Hot
- Warm
- Cold

The average greenhouse temperature of hot greenhouses is between 20-24oC and the temperature in these greenhouses does not fall below 18oC. Heat-loving plants should be grown in these greenhouses. In warm greenhouses, the temperature is between 10-20oC. Cold greenhouses are greenhouses with an internal temperature between 0-10oC and no heating is done in these greenhouses. For this reason, these greenhouses can be used for plant cultivation in temperate regions with a suitable climate. These greenhouses are used in seed growing to help keep them cool and artificially bloom.

2.2.5. Greenhouse Types According to Roof Frame

Roofs of greenhouses; It can be simple, gable and with a rounded roof. Simple roofed greenhouses are single-sided and the greenhouse is based on a wall.

Gable roof greenhouses have two roof surfaces. If these roof surfaces are equal to each other, it is called isosceles, otherwise it is called non-conjugate gable roof. This type of greenhouses can receive more light by installing them in the east-west direction. M-type roof shape emerges with the combination of gable roofs in block greenhouses.

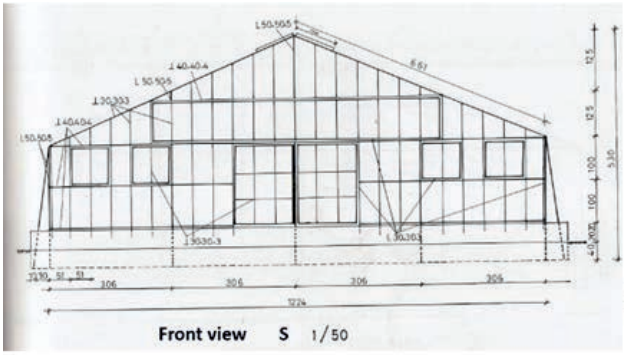


Figure 9: Isosceles Gable Roof

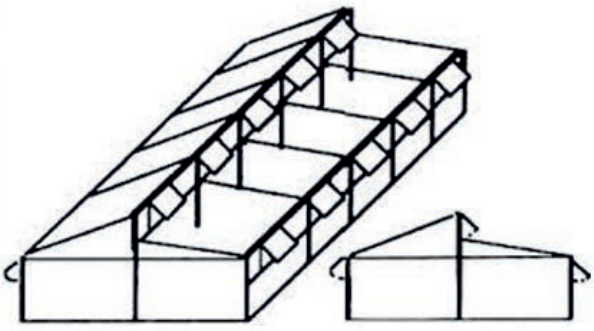


Figure 10: Non-Conjugate Gable Roof

Round-roofed greenhouses are roof-type greenhouses that can make the most use of sunlight. The use of plastic as a cover material reduces its cost. This type of round roof greenhouses can be set up individually or in blocks.

Picture 9-10: Individual and Block Greenhouses with Round Roofs

2.2.6. Greenhouses According to Utilization Types

Greenhouses according to their utilization forms;

- Cultivation,
- Conservation and display,
- Production,
- Research greenhouses are divided into four groups.

In cultivation greenhouses, the soil in the greenhouse is used for direct cultivation. Conservation and display greenhouses are established for the purpose of growing and selling potted flowers that do not grow in the region where they are established. In the production greenhouses, seedlings, seeds and cuttings are produced. Research greenhouses have almost all possibilities for many researches to take place, and university greenhouses are examples of these greenhouses.

2.2.7. Greenhouses by Cover Material

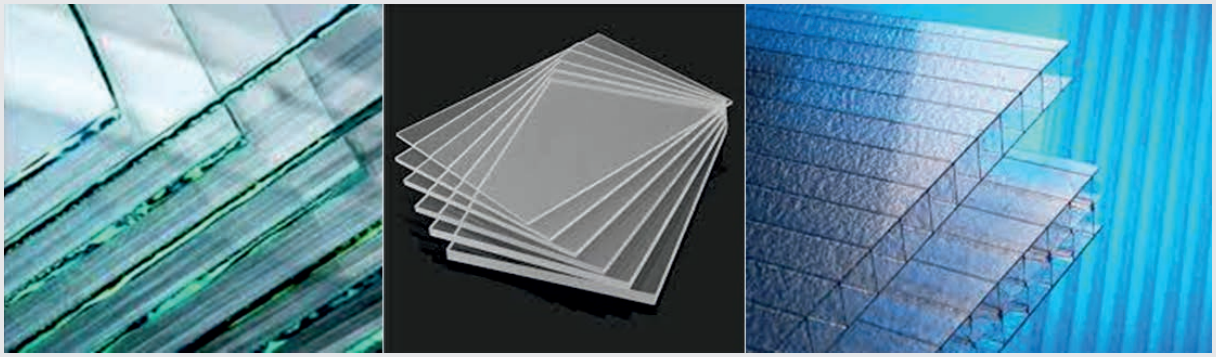
Greenhouses in terms of cover material; are classified as glass, plastic, artificial fiber and plexicam greenhouses.

Glasses are classified according to their thickness and wire content. While the light transmittance and durability of glass greenhouses are an advantage, their high cost is a disadvantage.

Plastic covered greenhouse applications are becoming widespread. The most commonly used plastics are PVC (polyvinylchloride) and PE (polyethylene). Plastic material wears out quickly and is torn from external factors. Their lifespan ranges from 6 months to 1-2 years.

Fiberglass cover is available in corrugated panels or in flat rolls. It is easy to work, a simple greenhouse can be covered with fiberglass material in 1-2 days. Most greenhouse planners prefer corrugated fiberglass panels on the roof and plain fiberglass or glass on the side walls.

Plexicam single or double layer acrylic glasses are more useful than glass. It has advantages such as cutting, puncturing, chipping and sticking while being used.



Picture11: Examples of Covering Material Used in Greenhouses (Glass, Plexicam, Policam)

2.2.8. Greenhouses by Skeleton Material

Greenhouses according to the skeleton material; are classified as wood, iron, concrete and aluminum greenhouses.

The oldest known skeletal material is wood, but due to its rapid decay, alternative skeletal systems have been tried. Wooden skeletons were replaced by iron skeletons, which had to be putty and painted over time. Concrete, on the other hand, is used together with other skeleton materials in the construction of greenhouse foundations rather than the skeleton material.

In recent years, aluminum, which stands out with its lightness and is not affected by adverse weather conditions, has started to be used as a skeleton material. But its cost is higher than other skeletal systems.

Although it is desired to be used in air-inflated greenhouses where the skeleton material is not used, it is not preferred because a small deformation in the plastic may cause the greenhouse to collapse.

2.2.9. Greenhouses by Being Portable

Greenhouses are divided into three as fixed, mobile and portable according to their portability.

Fixed greenhouses, which make up the majority of greenhouses, are built on a foundation. The soil fatigue problem encountered in fixed greenhouses has led to the emergence of mobile greenhouses. The skeleton of the movable greenhouses can move right or left, back and forth on the foundation. In hot weather, the greenhouse can be removed from the plants and normal farming can be resumed. Despite these advantages, the reason why it is not preferred is that its cost is 25% more than fixed greenhouses.

In recent years, instead of moving the greenhouses, portable greenhouses have been made by disassembling and reinstalling them.

2.3. Greenhouse Building Materials

Greenhouse building materials; can be grouped as foundation, skeleton and roof elements. In the selection and planning of these elements; The climate information of the region where the installation will be made, the type of plant intended to be grown, the size of the greenhouse business and the type of the enterprise should be evaluated.

Apart from this, the following should be taken into account when choosing the construction materials of the greenhouse.

- The building material to be used should be cheap, durable and light.
- It must be suitable for regular production
- It should save energy
- Installation and modification process should be easy
- Should not be affected by climatic conditions
- Desired conditions must be provided in the greenhouse.

2.3.1. Fundamentals

Greenhouse foundations are structures that carry the skeleton and greenhouse cover material and other loads and transmit them to the ground. Fundamentals;

- It connects the greenhouse to the soil.
- It transfers the entire load of the greenhouse to the soil.
- It protects the plants inside the greenhouse from adverse environmental conditions.

The foundation should be able to transmit all the load of the greenhouse on it with the help of columns to the ground without cracking, splitting and splitting. In this way, breakage does not occur in glass greenhouses. If the foundation cannot carry the load transmitted on its ground, the static balance of the greenhouse will deteriorate and it will be difficult to open and close the doors and windows accordingly. As a result, the desired climatic conditions in the greenhouse cannot be achieved.

In glass greenhouses, a foundation pit is dug along the perimeter of the greenhouse with a width of 70 cm and a depth of 80-100 cm to make the foundation wall. If the security of the floor is not sufficient, reinforced concrete is made on the lower part.

Foundation walls are applied in two ways as underground and above ground. Subsoil foundation walls are important in heavier glass and man-made fiber greenhouses.

The foundation walls of plastic-covered wooden greenhouses are made of brick, concrete, briquette, concrete or stone to carry excess loads. In order to protect the greenhouse skeleton in these greenhouses, rectangular or round concrete layers are poured on the feet of the greenhouse skeleton, and the elements that make up the greenhouse skeleton are connected to the foundation. In this way, negative effects such as the overturning of the greenhouse due to the wind and its dismantling are prevented.

Above ground greenhouse walls are mostly built to protect the cover material of the greenhouse and to prevent rain and snow waters. If the production is done on the ground floor of the greenhouse, low walls of 20-30 cm high are designed to prevent shading. If the greenhouse is designed for potted plant cultivation, if a raised bench or table is to be built, the high wall is built as 60-70 cm.

Picture12: Above Ground Foundation Wall

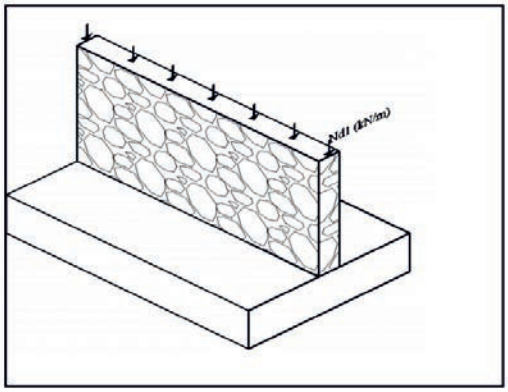


Figure 11: Underground Foundation Wall

A drainage system should be installed around the greenhouse to protect the greenhouse foundations from flooding. Especially the drainage system to be built around the block greenhouses is provided by pipes laid in trenches dug at a depth of 75-100 cm at a distance of 100 cm from the foundation walls.

2.3.2. Greenhouse Skeleton

The greenhouse skeleton is the structural unit that starts after the foundation and transmits the weight and load of the greenhouse to the greenhouse foundation. Skeleton part; It consists of uprights, roof trusses, rafters, drip and gutters, and covering material. The frame material can be of iron, galvanized iron, steel, aluminum and wood material. Wooden skeleton materials are generally preferred in greenhouses with plastic cover material. In greenhouses whose skeleton material is steel, the steels must be painted regularly. Aluminum skeleton material is more expensive compared to other materials.

The features of the elements that make up the skeleton should be as follows;

- It should be robust, light and cheap,
- It should be easy to install,
- Shading should be less,
- Heat loss should be low.

Columns, ie struts; The roof is the structural elements that transmit the weight to the foundation. Wood, steel and aluminum materials can be used. Concrete is not preferred in the construction of the columns as it will cause shading in the greenhouse. Columns must be strong in order to protect the greenhouse structure in individual and block greenhouses.

Columns, which are considered as load-bearing in greenhouses, are placed at equal intervals with the roof beams, as they carry the loads on the roof beams. The planning of these pillars is designed at certain intervals according to the skeleton material and cover material to be used.

The column height is the height between the greenhouse beam and the foundation walls. This height varies according to the climatic conditions of the region and the plants to be grown. In block greenhouses, on the other hand, the height of the uprights should be shortened in one direction so that the precipitation waters are removed. If there is a slope in a certain direction for surface irrigation methods or drainage systems in a greenhouse, the gutters that will remove the rain water must be adapted to this slope.

2.3.3. Roof Elements

The roof elements that cover the greenhouses from above are grouped under two headings as the skeleton forming the roof and the roofing material. The greenhouse roof should be able to carry the weight of the elements that make up the roof, the transparent covering material that completely covers the roof, snow and rain water, the weight of the workers climbing the roof and the plants hanging on the roof.

Greenhouse roof skeleton; It consists of rafter, purlin and roof truss.

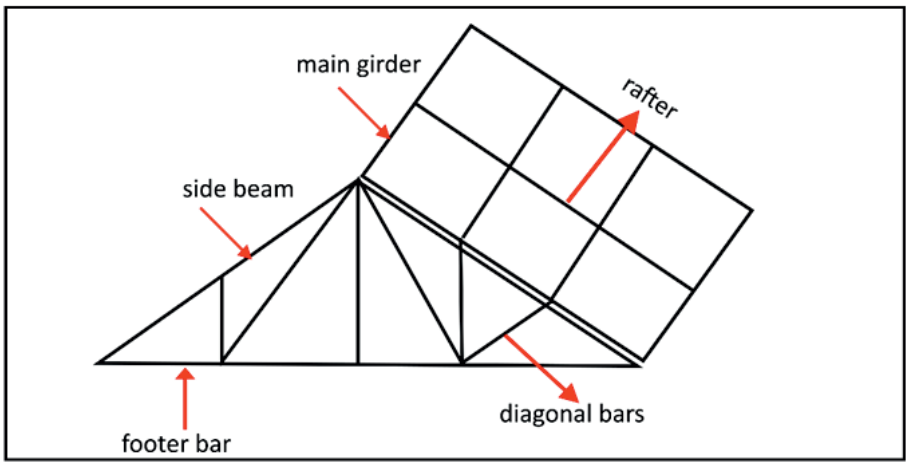


Figure 12: Greenhouse Roof Elements

Roof trusses are the elements that connect the pillars to each other in width, carry the roof load and form the roof. It is built in different ways depending on the width of the greenhouse and the load it will carry. Purlins are the structures that carry the load in the greenhouse, connecting the uprights and the roof trusses. The rafters (beams) ensure that the covering material is attached. The beams are placed on the purlins. The fewer the number of beams, the more shaded the greenhouse will be. The windbreaks are connected to each other crosswise at certain points on the roof and side walls to provide resistance against wind power in the greenhouse. It is generally used in large greenhouses. The number of windbreaks is proportional to the size of the greenhouse. Droppers and troughs are troughs made to collect the condensed water drops inside the greenhouse. Droppers are made on the part where the roof and side walls meet. On the other hand, in block greenhouses, gutters are made for the collection and flow of melted snow water and rain water. Dropper and gutter material varies according to cover and skeleton material. For example, in glass greenhouses, the gutter material is made of aluminum or galvanized sheet in U or V shape.

2.3.4. Cover Material

Certain covering materials; soft plastic, hard plastic and glass. Cover materials are the main factor in creating ecological conditions in the greenhouse. The sun rays coming to the cover material are reflected, absorbed or passed into the greenhouse. Covering materials should have features such as durability, heat insulation, ease of covering and being economical, as well as light transmittance.

Glass greenhouses have higher light transmittance than greenhouses covered with plastic and hard plastic. The most commonly used type of plastics in greenhouse cultivation are soft plastics as they have low specific gravity, are resistant to abrasion, have low cost, are easy to coat and require less labor. Plastic materials attract dust and are difficult to wash. In addition, condensation is high in the greenhouse. Water vapor glides on the plastic surface with difficulty and reduces the light transmittance of the plastic.

Glass has a low ability to transmit heat waves. That's why glass greenhouses heat up slower and cool down slower. Glass material has a high cost of installation and modification compared to other covering materials. Since the surface is easy to clean, there is no decrease in light transmittance and can be used for a long time.

We can list the benefits of glass cover material as follows:

- It is easy to provide a suitable environment for plant cultivation.
- It extends the production time, thus allowing the product to be found in the market at all times.
- The amount of product obtained per unit area is higher.
- Disease in the soil, etc. It's easier to deal with.
- Glass cover increases economy in operation.

Glasses preferred in greenhouses are of a certain standard. Glass thickness varies between 2 and 5 mm depending on the facade and area to be used. For example, 2-3 mm thick glasses are preferred on the side walls, and thicker, 3-5 mm thick glasses are preferred for covering the roof.

2.3.5. Doors

It is the element where the entrances and exits to the greenhouse are made. In general, it is made of transparent, light-transmitting materials such as greenhouse cover materials.

Doors should be designed with at least one door in each compartment to enable adults to work effectively. The width of the doors is 90-180 cm and the height is 2 m. Doors in greenhouses where mechanized agriculture is carried out are designed as double-winged or sliding. In tall greenhouses, there should be doors on both sides to prevent loss of labor. Doors should be designed in such a way that they do not cause heat loss.

Picture 13-14: Greenhouse Door Examples

2.3.6. Ventilation Openings

Ventilation openings are natural ventilation elements used to provide heat and moisture accumulation in the greenhouse and suitable conditions for the grown plant.

The most important task of the ventilation openings is to discharge the humid and hot air out of the greenhouse. The moisture accumulating in the greenhouse can adversely affect the growing plants. It also reduces the light transmittance due to the droplets. These undesirable events are naturally eliminated with ventilation openings. At the same time, ventilation is used to maintain the carbon dioxide and oxygen balance in the greenhouse.

Ventilation openings are made on both sides of the greenhouse roof ridge to provide good ventilation in the greenhouse. If there is not enough ventilation opening in the roof ridge, windows should be opened. Natural ventilation areas should be between 1/4-1/6 of the total greenhouse area. These openings should be adjusted according to environmental conditions when necessary. Since the heated and humidified air accumulates on the greenhouse roofs, making the ventilation openings on the side walls adversely affects the success of the targeted ventilation.

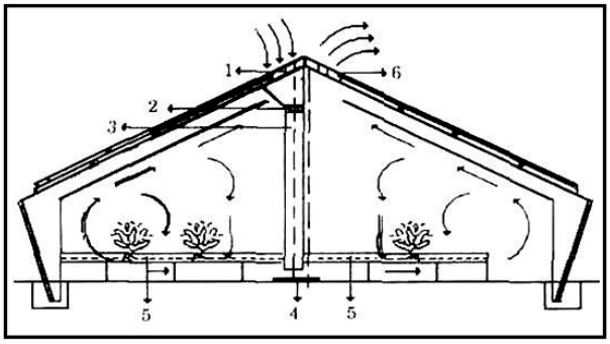


Figure 13: Greenhouse Ventilation Openings

2.4. Loads Affecting the Greenhouse

One of the most important factors to be considered in greenhouse structures is the loads that may come on the building elements. The loads on the greenhouse are effective in the formation of deformations in the greenhouses. Greenhouse loads should be inexpensive, light, durable, low in heat conduction, and easy to install, so as not to cause shadows. The elements that make up the structure must be in the smallest cross-sectional area that can safely carry the loads. The effective loads on the greenhouse construction elements are as follows:

- Fixed Loads
- Live Loads

2.4.1. Fixed Loads

The constant loads in the greenhouse consist of the weights of the roof elements and the weights of the systems suspended in the greenhouse.

The weights of the roof elements, the roof, rafters, purlins and beams of the covering material covering the greenhouse, should be known how much load it gives to the unit area of the horizontal plane. While this is not taken into account in light materials such as plastic, it is 2.5-3 kg per square meter in glass cover material.

The weight of the hanging systems in the greenhouse are the loads created by the heating and cooling systems connected to the greenhouse skeleton systems.

2.4.2. Live Loads

Wind, snow, the weight of the plants hanging on the roof and the weight of the worker climbing the roof for any purpose, as well as the dynamic effect of the earthquake can be given as examples of live loads.

Wind load is one of the most taken into account in greenhouse planning. While the wind creates a pressure force in the direction it blows, it creates a suction force on the other side. Greenhouse doors and windows should be closed on windy days. Otherwise, it may cause overturning by creating a suction force in the greenhouse. Plastic greenhouses cannot resist the effect of the lifting force due to the suction force of the wind due to the lightness of the roof material and the lightness of the skeleton system. For this reason, the connection of the roof elements should be strong, the cover should be supported with galvanized wire or wooden laths to prevent ballooning. Where necessary, generations should be discarded from the outside of the greenhouse.

Snow load is not calculated when designing greenhouses in areas where there is no or less snowfall, in enterprises with a high roof slope, in heated greenhouses and in places with high wind.

In order to obtain more products from the unit area, some vegetables are hung on the greenhouse roofs with ropes or different apparatus. The weight of these plants increases as the fruit is formed. However, these loads are not considered as roof element loads by being attached to the steel wires at the pillar heads.

Greenhouses should be designed in such a way that they can carry the weight of the worker, both during the installation phase and in the case of modifications.

3. New Techniques in Greenhouse Cultivation

With the increasing population, the need for food also increases at the same rate. In order to obtain a sufficient amount of product in every season, it is ensured that the business is maintained by creating different environmental conditions outside the traditional greenhouses or using different sources. Experts who have done research on this subject have developed soilless agriculture today by working on the cultivation of fruits and vegetables in greenhouses on unsuitable soils. Studies are carried out for the development of greenhouse agriculture by reducing heating costs in regions with unfavorable climates by using geothermal resources for purposes such as heating greenhouses.

3.1. Soilless Agriculture

Soilless agriculture is the cultivation of plants by providing all kinds of growing conditions that do not contain soil. As a growing medium, only nutrient solution can be used, as well as various organic and inorganic solid materials.

The purpose of soilless agriculture;

- Ensuring plant development with nutrient solutions
- Meeting the water and nutrient needs of the plant in a stress-free way
- It is to meet these needs in the most economical way.

Although soilless agriculture is a method mostly applied in greenhouse cultivation, it is possible to encounter applications in open areas today. Researchers have shown that tomatoes grown with soilless agriculture are at least as high quality as tomatoes grown in soil. With the dissemination of this system, successful greenhouse activities can be carried out in stony, rocky, salty and barren areas unsuitable for agriculture and in areas with high ground water.

Picture15-16: Soilless Agricultural Practices

We can list the reasons for soilless farming practices as follows:

1.Soil loss: Due to the rapid population growth, the lands to be cultivated may be insufficient to meet the needed nutrients. Erosion, barrenness, settlement in agricultural lands and separation into tourism areas increase the loss of soil.

2.Soil fatigue: Growing the same product for many years in a row in greenhouses causes soil fatigue. This reduces the fertility of the soil. The resulting soil fatigue can be eliminated by changing the soil and the product to be grown, but this method is both impractical and economically costly for the producer. In addition, despite modern agricultural practices, the desired yield and quality products cannot be grown.

3.Disease, pest and weed problem: Immune diseases, pests and weeds are a major problem in areas where intensive agriculture is carried out and the same product is grown continuously.

4.Excessive fertilizer and water consumption: Fertilizers are used in greenhouses to increase plant yield and quality. The use of too much fertilizer can cause environmental pollution, and it also brings fertilizer problems in the future. Again, the amount of water that should be used for irrigation of agricultural areas is not known. In addition, since the soil absorbs water, there is 4-5 times more water expenditure than soilless agriculture.

5.Energy and labor saving: There is a need for labor in all areas where soil farming is carried out. There are many work items such as processing the soil, preparing for planting, hoeing, making it suitable for irrigation, weed control. A lot of energy is needed to operate many tools and equipment, especially tractors and coupling equipment.

Picture17-18: Soilless Agricultural Practices

The main benefits of hydroponic farming are:

- Soils unsuitable for agriculture are evaluated.
- The nutritional value and pH value of the products are easily provided. With nutrient solutions, the balance of macro and micro elements is provided to the desired extent.
- Root diseases are detected less by aeration of the root part.
- Less area and water is needed compared to soild agriculture. It saves water as the same water can be reused in closed systems.
- It saves energy and labor.
- In addition to providing better fruit quality, it allows to obtain products that visually satisfy the consumer.
- Provides high product internal quality (sugar, vitamin, mineral, dry matter content)
- High production/income is achieved. Product and yield planted per unit area are higher.
- It allows crops to be grown for a long time. Thus, it is possible to see the product in the market throughout the year.
- Earlier harvest can be achieved as it is a controlled cultivation process.
- The sales area is high.
- It enables the development of industries.
- Less pesticides are used.
- Flowering can be controlled.
- The time between two harvests is short.

Picture 19: Soilless Agricultural Practices

Some disadvantages of soilless agriculture are as follows:

- The initial facility setup cost is high.
- Qualified personnel is required.
- There are technological risks due to not being able to keep up with the developing technology and the realization of related errors.
- The system must be constantly monitored.
- The nutrient solutions and chemicals used can leave a negative impression on the consumer.
- If there is no source such as geothermal energy for the heating of greenhouses, the cost of energy increases.

3.2. Geothermal Greenhouse

The fact that the heat loss in greenhouses is very high compared to reinforced concrete structures, especially at night, the limited use of solar energy, the cost of systems that meet the need for heating with fossil fuels, made greenhouse cultivation limited in the spring and autumn seasons. For this reason, using geothermal energy as a heating source in geographies with geothermal resources makes greenhouse cultivation suitable for all seasons, as well as greenhouse cultivation in cold climates that are not suitable for greenhouse cultivation activities. Thus, while the product grown in that geography spreads to the market earlier, it also brings many positive results such as the employment of adults and the prevention of unplanned urbanization in the cities due to the decrease in migration in the region.

Greenhouse heating systems with geothermal energy are a collection of elements used to transport the geothermal fluid from the area where it is extracted to the areas where the consumer is located. These systems can be technically grouped as heating systems placed on the soil surface, inside or on growing tables, air heating systems using fans and heat exchangers, and combined heating systems. It has been determined that the most suitable method for the use of geothermal source among heating systems is the heating system made from the ground or underground. This system is based on the principle of heating the source by passing through pipes buried at a certain depth and intervals fed from the same source, and supporting it with an ambient air heating system ensures the best results.

3.2.1. Geothermal Greenhouse in the World

Global geothermal energy production was realized as 15,854 MW at the end of 2021. Despite all the difficulties of the pandemic, many countries have added new capacity. In 2021, the top 10 countries in terms of installed power generation capacity are respectively; USA, Indonesia, Philippines, Turkey, New Zealand, Mexico, Italy, Kenya, Iceland and Japan.

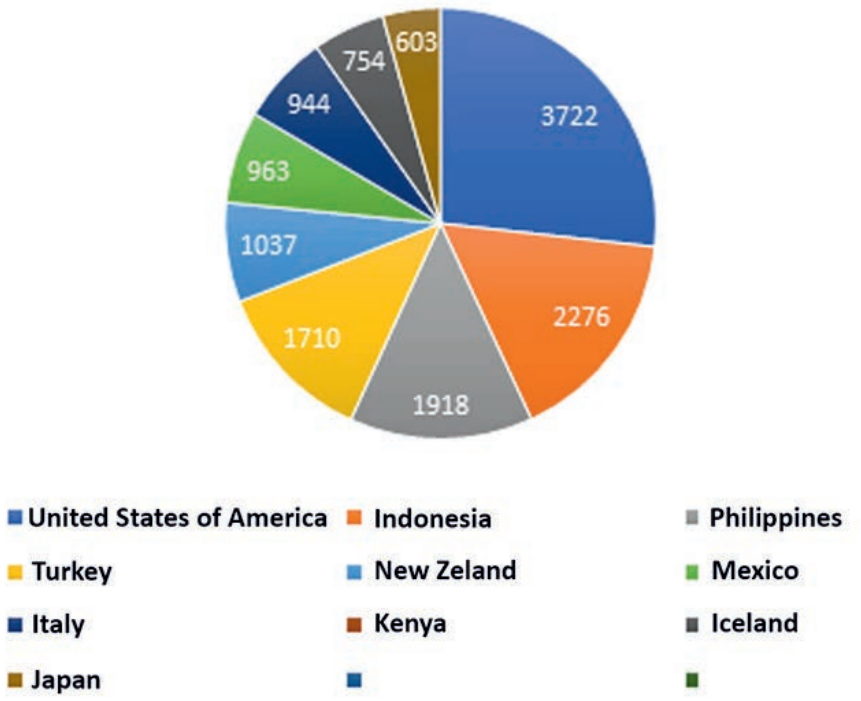


Figure 14: World Geothermal Energy Power Top Ten Country Distribution Chart

According to the 2015 World Geothermal Congress report, it is aimed to increase the capacity to 250,000 MWt with installed geothermal power plants until 2050.

When Table 1 is examined, while the capacity used for greenhouse heating was 1.085 MW in 1995, this value increased to 1.830 MW in 2015. In this increase, the factors that cause the increase in soilless agricultural activities can be shown.

Usage areas	1995	2000	2005	2010	2015
Geothermal Heat Pumps	1.854	5.275	15.384	33.134	49.898
Space Heating	**2.579**	**3.263**	**4366**	**5.394**	**7.556**
Greenhouse Heating	1.085	1.246	1.404	1.544	1.830
Aquaculture	**1.097**	**605**	**616**	**653**	**695**
Agricultural Drying	67	74	157	125	161
Industrial Use	**544**	**474**	**484**	**533**	**610**
Spa	**1.085**	**3.957**	**5.401**	**6.700**	**9.140**
Cooling-Snow Melting	**115**	**114**	**371**	**368**	**360**
Other	**238**	**137**	**86**	**42**	**79**
Total	**8.664**	**15.145**	**28.269**	**48.493**	**70.329**

Table 1: World Geothermal Congress Data

When the table is examined, the installed capacity value of greenhouse heating increases by 69% from 1995 to 2015. According to 2015 data, the energy used for greenhouse heating in annual geothermal energy use increased by 70% between 1995 and 2015.

The leading countries in greenhouse cultivation using geothermal resources in the world are Turkey, Hungary, Russia, China and Italy. In addition, there are geothermal applications in tree seedlings in the USA and in banana orchards in Iceland. The use of geothermal energy for agricultural purposes draws attention in the direct applications of geothermal resource in European countries such as Hungary, Macedonia, Bulgaria and Serbia.

3.2.2. Geothermal Greenhouse in Turkey

In Turkey, which has an important place in the world in terms of geothermal energy potential, geothermal energy has various usage areas such as space heating, central heating, greenhouse heating, agricultural drying, spa and geothermal heat pumps.

When geothermal energy studies in Turkey by years were compared by the General Directorate of Mineral Research and Exploration (MTA), the following results were obtained.

- The number of fields suitable for electricity generation increased from 16 in 2002 to 25 in 2017.
- While greenhouse heating was 500 decares in 2002, it increased to 3.931 decares in 2017, with an increase of 686%.
- While residential heating was 30,000 houses in 2002, it increased to 114,567 houses in 2017.
- While the installed power in electricity generation was 15 MW in 2002, it increased to 1.052 MW as of the end of 2017.
- The apparent heat capacity of the country, on the other hand, increased from 3,000 MW in 2002 to 15,500 MW in 2017, resulting in a 416% increase.

According to 2013 data in Turkey, plant cultivation is carried out with a geothermal greenhouse in a total of 147 enterprises. In this denominator, geothermal greenhouse cultivation is carried out in İzmir with a share of 24% and in Manisa with a slice of 23.42%.

3.2.3. Considerations in the Installation of Geothermal Greenhouses

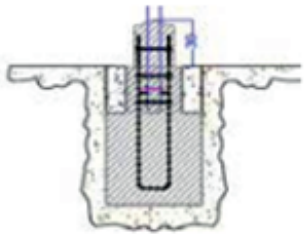
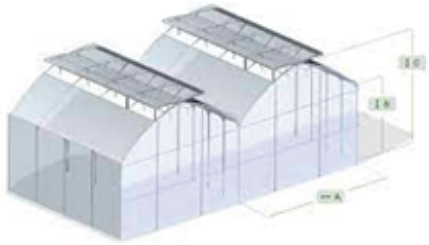
In order for greenhouse activities to be profitable, an average greenhouse should be at least 20,000 m2, based on market demand and the product obtained from the unit area.

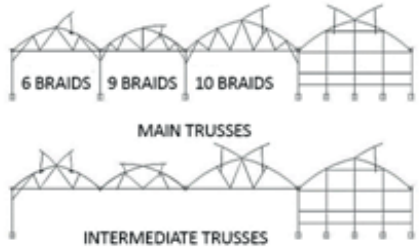
Especially in soilless agriculture, it is necessary to constantly monitor the current conditions on the computer. The optimum conditions needed by the plant to be grown are determined and entered into the computers and these parameters are followed by the sensors placed in the greenhouse.

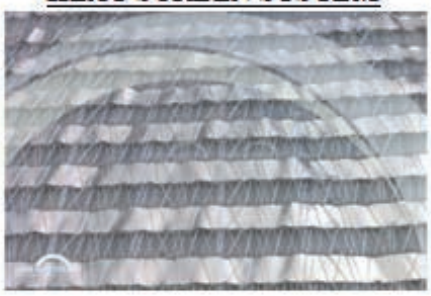
By detecting the change in any parameter, it is ensured that the desired values are reached as soon as possible through the system. The technical characteristics of the greenhouse planned to be established in this direction should be as follows;

- Single top ventilated gothic roof
- Upper roof part is PE nylon,
- Polycarbonate coating on the sides
- Automation system (heating, irrigation, fertilization, curtain systems)

The technical specifications for a sample greenhouse study are as follows.

LAND LEVELING	On the land where the greenhouse will be established, a slope of 80 cm will be given at every 100 m distance according to the current direction. According to the complete land structure, a land with an 8/1000 slope from the middle to two in one direction south or north-south direction should be created. The ground is excavated at a depth of 1,2 m and cleared of stones and rocks.
ANCHOR PIT AND CONCRETE 	Anchor pits with a diameter of 60 cm and a depth of 120 cm are prepared. The steel profiles are placed in the anchor pits on the scale. Accurate placement is made using measuring instruments and concrete is poured, supported by rebars.
ENVIRONMENTAL FOUNDATION AND SIDE CURTAIN CONCRETE	The foundation concrete is made according to the dimensions of the greenhouse in 50x20 dimensions, in accordance with the slope of the land.
Scissors  **Gothic Type Greenhouse**	The load distribution is balanced and strong. The loads are divided into 5 equal parts and the loads are distributed evenly and evenly to the system by using 10 knitting materials. Connections converge at nodes and loads are balanced more accurately. Gothic type greenhouses can receive more daylight and evacuation of water vapor is provided

 **Gothic Type Truss Structure**	with condensation gutters. Provides larger indoor air volume than conventional greenhouses
STEEL CONSTRUCTION ELEMENTS	It consists of oval spring tube, columns, scissor connections, screws and bolts, clips. Technical details vary according to the preferred greenhouse.
VENTILATION SYSTEM	There are two ventilation openings in each tunnel. Ventilation is controlled by automation. Fly nets should be installed in the ventilation openings. Thanks to the ventilation system, an air flow is created that sweeps over the roof and helps the flow inside and outside. In this way, it provides a successful dehumidification opportunity.
FLY TIGHT	It should be used in every window and ventilation. Air permeability is excellent. Also, there is no need for tulle for the bee.

HEAT SCREEN SYSTEM 	While it is used for cooling and shading in the summer season, it also provides energy savings in the winter season.
PLANT HANGER WIRES 	Each column is mounted at a height of 4.5 m from 12 mm galvanized ropes along the tunnel fronts, front and rear facades. Soilless agriculture is carried out in greenhouses where a hanging system will be installed. Coconut fiber or rock wool growing bags are used on hanging plant growing beds. This system is suspended on the trusses of greenhouses. With this design, the drainage works properly and the under-bed air circulation works without any problems.
PLANT GROWING MEDIA 	Coconut shell slabs are used in hydroponic farming. Cocopet usage purposes; • Provides a completely natural growing environment. • It does not contain any additives. • It has high water holding capacity. • It provides rapid development of seeds and plants. • Provides more intensive rooting. • Efficiency is high. • It provides development and production control. • Producer agricultural consultancy support is available.

IRRIGATION SYSTEMS 	Water silos are made for use in greenhouses. The amount of water in the water silos should be the capacity to meet the daily need of the greenhouse. *Drip irrigation system:* It is an automation irrigation system based on the principle of slowly dripping water to the roots of plants by being buried on the soil surface or under the surface. In this system, the aim is to minimize evaporation by applying water to the root of the plant. Water drips through a network of valves, tubing, and emitters.
IRRIGATION FERTILIZATION AUTOMATION	Automation system consists of unit and system. Irrigation unit, pH control to the irrigation room, PC connection, 8 sector irrigation valve controlled, fully automatic fertilization irrigation machine is the most used system.
HEATING SYSTEM	Distribution collectors, main distribution pipes, subfloor system, under gutter heating, under gutter heating systems in indoor heating systems vary according to the region where the greenhouses are built.

Table 3: Sample Greenhouse Model Technical

Four heating systems can be mentioned in the heating of greenhouses with geothermal energy.

- Finned pipe (serpentine) systems
- Fan coil systems
  - o Standard heating units
  - o Low temperature heating units
- Ground heating systems
- Heating systems with straight pipes (natural convection)

Serpentine systems: It is usually made by adding round and rectangular fins of steel or aluminum.

Picture 19: Finned Tubes (Serpentines)

In order to calculate the coil length, the capacity given for the unit length at the water inlet at a certain temperature is multiplied by the correction factors for the different temperature inlet, and the length suitable for the capacity is determined. Since the pipe length will be longer in natural convection serpentine systems, it is not practical for greenhouse heating. However, the maintenance costs are very low and the need for no fans provides energy savings.

Forced convection serpentine units: Since the preference of copper pipes in these systems will cause corrosion, geothermal water should not be used directly. Temperature control is provided with the help of fan. While it can meet very high heating needs, it allows rapid intervention in sudden temperature drops.

Ground heating systems: Pipes placed under the ground first heat the soil and then the greenhouse air. The most common pipe material is polybutylene pipes, which can withstand very high temperatures. There is a need for a secondary heater at peak loads, considering the possibility of heating the greenhouses from the ground, the soil getting too hot and damaging the plants. The way to be followed in the design is as follows;

- Finding the thermal load of the greenhouse,
- Calculation of the required floor temperature accordingly,
- Calculation of pipe diameters, depth and spacing.

Picture 20: Ground Heating System

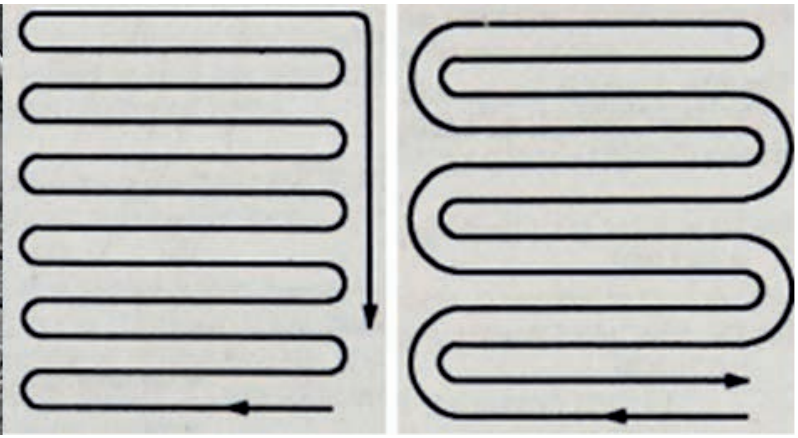


Figure 14: Single and Double Row Slabs

The recommended temperature for greenhouses with people inside is 30oC. When applying these systems, if the pipe length is too long in the calculations, pressure losses should be reduced; For this, the installation is divided into parallel lines and pressure losses are balanced. Another issue is that the heating is carried out homogeneously. If the temperature drop in the pipe is more than about 8oC, double-row laying as in Figure 14 will ensure that the heat flow is more homogeneous throughout the greenhouse.

Straight pipe systems: In this system, polybutylene or steel pipes of small diameter are positioned in small clusters at a certain height from the surface, closer to the ground if possible. Intermediate heat exchanger for temperature control is done by means of valves. It is a common alternative with precise temperature control in warm climates due to the high cost of pipes in adapting to cold climates. The design is as follows;

- Determination of suitable geothermal fluid flow rate
- Calculating heat losses, determining the temperature drop in the water flow to be provided and the average water temperature in the installation
- Calculation of the amount of heat that 1m pipe length can give at average water temperature
- Finding the necessary pipe length to meet the heat requirement.

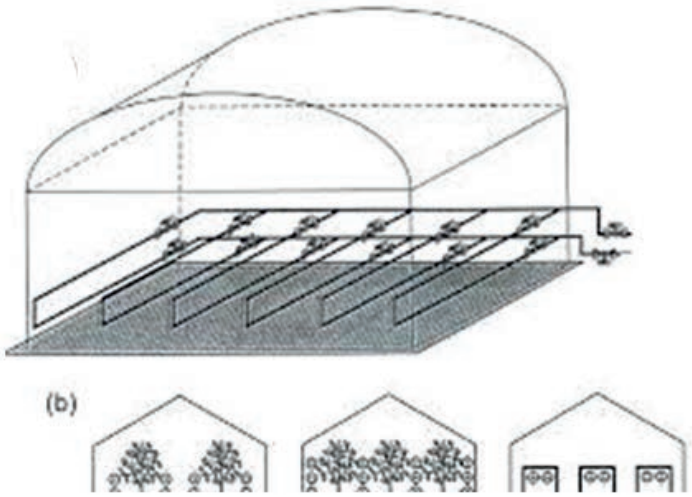


Figure 15: Example of Straight Pipe System

Tichelman method: Homogeneous heating is very important for a greenhouse. In this, hydraulic balance must be provided. The desired hydraulic balance is achieved by laying the heating pipes according to the Tichelman Method. Because laying the return line of each heating element in the shortest way keeps the pipe length of each element constant and this causes equal heat loss.
In this way, equal fluid flow always passes through the system.

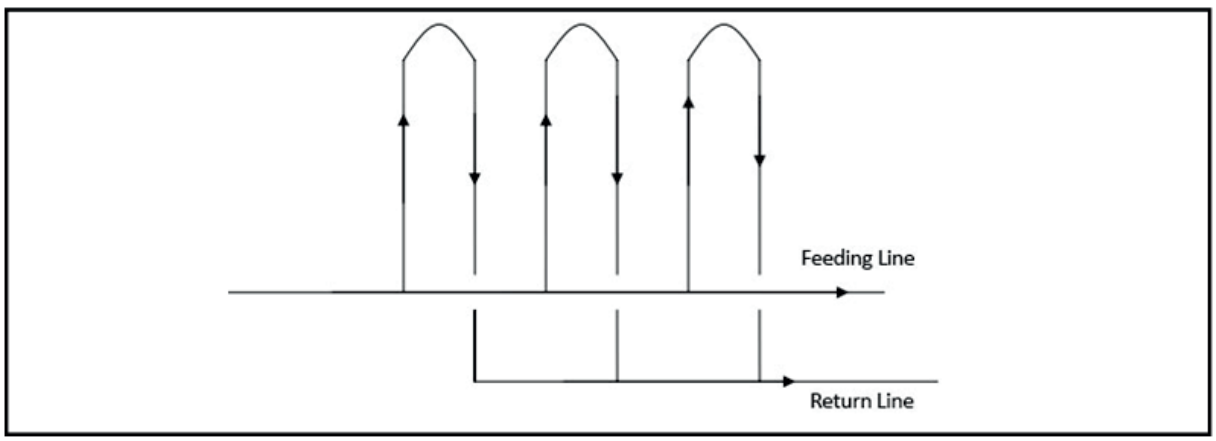


Figure 16: Tichelman Method

Heat exchangers: Separating the geothermal fluid from the clean water line and providing temperature control are the main tasks.
The temperature of the heating pipe must be controlled to ensure temperature control. This is most easily achieved by changing the flow rate of the geothermal fluid entering the heat exchanger.
Plate heat exchangers are most commonly used in geothermal applications. Corrosion resistant titanium or stainless steel plates are used as heat exchanger material. However, sometimes it has been observed that stainless steel pipes are also subject to corrosion.

3.2.4. Advantages and Disadvantages of Traditional Greenhouse Cultivation

We can list the advantages of using geothermal energy for greenhouse heating as follows:

- Low temperature (40-45 oC) geothermal fluid can be used in greenhouse cultivation
- Creating an alternative as a heater for the heating of greenhouses in cold months
- Renewable, environmentally friendly and locally sourced compared to other fuel sources
- Heating costs lead producers to spring and autumn cultivation, which causes prices to rise excessively due to the low product supply during the transition periods.

With the use of geothermal resource especially in greenhouse cultivation; It is envisaged to establish organized greenhouse zones with low production costs, reliable and traceable, high competitiveness, high brand value and modern production.

The disadvantages of using geothermal resources for heating greenhouses, high investment cost, need for trained labor force, and integration with systems that require continuous monitoring can be shown among the disadvantages.

GENERAL MEASUREMENT AND EVALUATION

• If the information given in the sentences below is correct (c), write it (i) if it is incorrect.

(…) 1. The installation cost of glass greenhouses is lower than other covering materials.
(…) 2. Regions located in the temperate climate zone are the most suitable places for greenhouse operations.
(…) 3. Known for its abundance of greenhouses, the region also known as the White Roof City is the Spanish city of Almeria.
(…) 4. In order to meet the water need in the areas where greenhouses will be established, rainwater collection areas can be created.
(…) 5. Geothermal energy is an environmentally friendly energy source used for heating greenhouses.
(…) 6. Developing technology is of little importance in determining greenhouse types.
(…) 7. Greenhouses with a round roof receive the sun's rays better than other greenhouses with a roof.
(…) 8. The shading of the greenhouse frame should be low.
(…) 9. There is no need for continuous control of the system in soilless agriculture.
(…) 10. Underground heating can be done in greenhouses with geothermal resources.

• Tick the correct one in the multiple choice questions below.

1.Which of the following information is incorrect?
A. The greenhouses to be established should be close to the roads.
B. Greenhouses should be designed considering environmental conditions and climate information.
C. The greenhouse light requirement is provided by fluorescents.
D. Natural events such as wind, snow load and rain affect the greenhouse design.

2.Which of the following is false information about greenhouse cultivation?
A.Greenhouse investment is high in the temperate climate zone.
B.High yields can be obtained even in small agricultural areas with greenhouses.
C.Provides more than one production opportunity during the year.
D.Plastic greenhouses are preferred more in Turkey.

3.Which of the following is an ecological factor in choosing a greenhouse location?
A. Temperature
B. Light
C. Soil and topography
D. All

4.Which of the following information is incorrect?
A. A suitable environment should be prepared for the plant to be grown in greenhouse cultivation.
B. Greenhouse heating systems are needed in cool climates.
C. Technological developments do not matter in greenhouse installation.
D. Greenhousing becomes a sector and offers job opportunities to adults.

5.Which of the following are the uses of greenhouses?
A. Do research
B. To earn economic income
C. For hobby purposes
D. All

6.Which of the following is incorrect?
A. If the covering material is glass, the most suitable frame material is wood.
B. Greenhouses are large, medium and small according to their size.
C. Individual greenhouses are greenhouses with a single roof.
D. Greenhouses for research purposes can be established in universities.

I. It should be cheap
II. May be affected by climatic conditions
III. It should save energy

7.Which of the above information is correct?
A.only I. B. I. ve III. C. only III. D) II. ve III.

8.Which of the following is true?
A. Only one door should be built in greenhouses to prevent heat loss.
B. Cover material should be preferred in such a way that it is not affected by environmental conditions.
C. Ventilation openings on the side walls provide effective ventilation.
D. In block greenhouse structures, gutters are used to reduce the effect of the wind.

9.Which of the following options is false information about soilless agriculture?
A. Plant nutritional needs are provided with nutrient solutions.
B. Water costs are lower compared to irrigated soil agriculture.
C. It also provides agricultural opportunities in areas unsuitable for agriculture.
D. None

10.Which of the following options is not an advantage of geothermal resources in greenhouse heating?
A.It is an alternative source for greenhouse heating in cold weather.
B.It is environmentally friendly compared to other heating fuels.
C.Business establishment cost is low.
D.It provides a reliable, traceable, high brand value production opportunity.

ANSWER KEY

Below is the answer key for the questions with correct/incorrect options.

1	i
2	c
3	c
4	c
5	c
6	i
7	c
8	c
9	i
10	c

Below is the answer key for the multiple choice questions.

1	C
2	A
3	D
4	C
5	D
6	A
7	B
8	B
9	D
10	C

MODULE INFO PAGE

NAME OF THE MODULE: GREENHOUSE AGRICULTURE

DURATION OF THE MODULE: 10 hours

PURPOSE OF THE MODULE: Within the scope of adult education, individuals will gain knowledge and skills about the definition and importance of greenhouse, plant cultivation in greenhouses in Europe and in major countries in the world, factors in choosing greenhouse location.

PREREQUISITES: This module has no prerequisites.

LEARNING OUTCOMES OF THE MODULE:

A. Greenhouse Agriculture and Its Importance

B. Growing Plants in Greenhouses Around the World

C. Growing Plants in Greenhouses in Turkey

D. Factors Influencing the Selection of the Greenhouse Location

ACHIEVEMENT	SUCCESS CRITERIA	
A	KNOWLEDGE	1. Know the definitions of greenhouse and greenhouse cultivation. 2. Know the importance of farming with greenhouse.
	SKILLS	1. Know and apply the definitions of greenhouse and greenhouse cultivation. 2. Have basic knowledge that can be benefited from greenhouse activities to grow crops.
B	KNOWLEDGE	1. Know how greenhouse activities in the world are divided according to climatic zones. 2. Gain knowledge about greenhouses which are preferred in cool, temperate and two climates.
	SKILLS	1. Can tell which types of greenhouses can be seen in the world and where.

		2. Have awareness about how greenhouse activities are carried out for climate zones.
C	KNOWLEDGE	1. Have information about the intensity of greenhouse activities in Turkey. 2. Depending on the temperate zone of Turkey, greenhouse cultivation will have the knowledge that it has the best location. 3. Gain information about greenhouse activities according to regions in Turkey. 4. Have information about which types of greenhouses are the most.
C	SKILLS	1. Awareness about how much of the greenhouse activities constitute the activities of agriculture in Turkey. 2. Awareness that the temperate zones are suitable for greenhouse activities. 3. Will be able to give information about greenhouse activities according to regions in Turkey. 4. Know and can apply which greenhouse types are suitable for Turkey due to its geographical location.
D	KNOWLEDGE	1. Gain knowledge about the factors affecting the selection of greenhouse location. 2. Know what ecological factors are. 3. Gain knowledge about the effect of irrigation water on site selection. 4. Gain knowledge about the effect of economic factors in the selection of greenhouse location.
	SKILLS	1. Can choose the right place before installing the greenhouse. 2. Know the ecological factors such as light, temperature, air movement, direction, soil in greenhouse installation and can choose the right greenhouse type to prevent the negative effects of these factors. 3. Know the importance of irrigation water, knows how to irrigate by collecting rain water.

REMARKS ON PRACTICE

1. It should be ensured that every adult who wants to have competence understands the subject.
2. During the module, the subject should be reinforced by using question-answer method, brainstorming and narration methods.

ASSESSMENT AND EVALUATION:

At the end of the training process, the student's achievements are determined with this module/(s) organized under the main heading of Growing Fruit, Vegetables and Ornamental Plants in Geothermal Greenhouses, which is prepared to evaluate the proficiency of individuals. These achievements are determined with general assessment and evaluation questions, and it is ensured that the success in the achievements is evaluated as a whole. Assessment parameters suitable for the achievements conveyed in assessment and evaluation activities are selected. The success criteria of learning outcomes are given in the table above.

NAME OF THE MODULE: GREENHOUSE TYPES AND BUILDING MATERIALS

DURATION OF THE MODULE: 18 hours

PURPOSE OF THE MODULE: Informing individuals about greenhouse types, classification of greenhouses, greenhouse construction materials and loads affecting the greenhouse within the scope of adult education.

PREREQUISITES: This module has no prerequisites.

LEARNING OUTCOMES OF THE MODULE:

A. Greenhouse Types

B. Classification of Greenhouses

C. Greenhouse building Materials

D. Loads Affecting the Greenhouse

ACHIEVEMENT	SUCCESS CRITERIA	
A	KNOWLEDGE	1. Have knowledge about greenhouse types. 2. Gain knowledge about the usage purposes of greenhouses. 3. Have information about greenhouse sizes. 4. Have information about the effect of the topographic and ecological characteristics of the place where the greenhouse will be installed on the greenhouse. 5. Gain knowledge about the effect of business' financial power. 6. Have information about the effects of tools and equipment in determining the greenhouse type. 7. Gain knowledge about the effect of the owner's taste and knowledge on the greenhouse type.
	SKILLS	1. Know the greenhouse types and can choose the appropriate greenhouse type. 2. Aware that greenhouses will be used for other purposes other than agriculture. 3. Will be able to determine the size required for the greenhouse according to factors such as the product to be grown, environmental conditions, financial power. 4. Can design or select the right greenhouse type suitable for the climate of the place to be installed.

		5. Know the importance of operating cost in the selection of greenhouse type and can compare cost and installation. 6. Will be able to choose a greenhouse type considering the tools and equipment to be used. 7. Know the effect of business owner's knowledge on greenhouse activities and have knowledge about greenhouse cultivation.
B	KNOWLEDGE	1. Have information about the classification criteria of greenhouses. 2. Have the knowledge to classify greenhouses according to their elders. 3. Have information about the establishment of greenhouses. 4. Gain knowledge about the grouping of greenhouses according to their structural skeletons. 5. Know the classification of greenhouses according to their temperatures. 6. Gain knowledge about the classification of greenhouses according to their utilization. 7. Gain knowledge about grouping according to the cover material used in greenhouses. 8. Gain knowledge about the grouping of skeleton materials used in greenhouses. 9. Have information about grouping greenhouses according to their portability.
	SKILLS	1. Classify greenhouses and select suitable greenhouse type. 2. Can select suitable greenhouse type among small, medium and large greenhouses. 3. Know that he can provide a more efficient agriculture by choosing a tower type greenhouse in smaller areas. 4. Know that the most suitable skeleton material is steel or aluminum. Wooden skeleton systems can be preferred as the appropriate skeleton.

		5. Greenhouse selection can be made at the appropriate temperature for the agricultural product to be grown. 6. Know how to benefit from the sun in the most effective way with round roof systems. 7. Aware that the light transmittance of greenhouses with glass cover material is high, and the cost of plastic ones is lower. 8. Implement portable or collectible greenhouse applications according to its economic power.
C	KNOWLEDGE	1. Have knowledge about greenhouse building materials. 2. Gain knowledge about the foundation of the greenhouse. 3. Gain knowledge about greenhouse skeleton. 4. Have information about greenhouse roof elements. 5. Gain knowledge about the covering material to be used in greenhouses. 6. Have knowledge about how to design doors in greenhouses. 7. Gain knowledge about ventilation openings in greenhouses.
	SKILLS	1. Know the properties of greenhouse building materials and can choose appropriate materials. 2. Depending on the greenhouse foundation to bear the entire load, can perform foundation work in accordance with greenhouse building materials. 3. Will be able to make appropriate choices according to the characteristics that the greenhouse skeleton should have. 4. Be more careful in matters such as column height and shading. 5. Know that the roof elements should be designed to carry the weight of rain water, snow, the worker on the roof and the covering material.

		6. Can make the right choice of cover materials under appropriate conditions and has a command of the differences between each other. 7. Can adjust the size and number of greenhouse doors according to the greenhouse size and purpose of use. 8. Know how to make ventilation openings in greenhouse design. Know that the most suitable place is the greenhouse roofs.
D	**KNOWLEDGE**	1. Have information about the loads affecting the greenhouse. 2. Gain knowledge about fixed loads. 3. Have information about moving loads.
	SKILLS	1. Know that the most important factors in the formation of greenhouse structures are loads. 2. Know that roof element weights and hanging plants are fixed elements. 3. Know that factors such as wind, snow, rain water are live loads and can take them into account in greenhouse design. Thus, when designing a greenhouse in a windy place, it can intervene by using windbreakers or by covering open areas.

REMARKS ON PRACTICE

1. It should be ensured that every adult who wants to have competence understands the subject.
2. During the module, the subject should be reinforced by using question-answer method, brainstorming and narration methods.

ASSESSMENT AND EVALUATION:

At the end of the training process, the student's achievements are determined with this module/(s) organized under the main heading of Growing Fruit, Vegetables and Ornamental Plants in Geothermal Greenhouses, which is prepared to evaluate the proficiency of individuals. These achievements are determined with general assessment and evaluation questions, and it is ensured that the success in the achievements is evaluated as a whole. Assessment parameters suitable for the achievements conveyed in assessment and evaluation activities are selected. The success criteria of learning outcomes are given in the table above.

NAME OF THE MODULE: NEW TECHNIQUES IN GREENHOUSE GROWING

DURATION OF THE MODULE: 62 hours

PURPOSE OF THE MODULE: Within the scope of adult education, to provide individuals with information about the advantages and disadvantages compared to traditional greenhouse cultivation, the use of greenhouses, the use of greenhouses, the use of soilless agriculture and geothermal resources with the effects of changing and developing technologies, and the geothermal greenhouse regulations.

PREREQUISITES: This module has no prerequisites.

LEARNING OUTCOMES OF THE MODULE:

A. Soilless agriculture

B. Geothermal resource

C. Considerations in the installation of Geothermal Greenhouses

D. Comparison with Traditional Greenhouse Cultivation

ACHIEVEMENT	SUCCESS CRITERIA	
A	KNOWLEDGE	1. Gain knowledge about soilless agriculture. 2. Gain knowledge about the reasons of soilless agricultural practices. 3. Know the advantages of soilless agriculture. 4. Gain knowledge about the disadvantages of soilless agriculture.
	SKILLS	1. Know that nutrient solutions are used for growing plants in soilless agriculture. 2. Aware that it can be installed even on infertile soils. 3. Compare the differences with traditional greenhouse cultivation and apply soilless agriculture according to the region and product to be grown. 4. Will be able to list the advantages and disadvantages of soilless agriculture.
B	KNOWLEDGE	1. Gain knowledge about the use of geothermal energy for heating greenhouses. 2. Gain knowledge about geothermal greenhouse cultivation in the world.

		3. Gain knowledge about geothermal greenhouse cultivation in Europe. 4. Gain knowledge about the plans related to geothermal greenhouse cultivation. 5. Have information about the legislations related to geothermal greenhouse cultivation.
	SKILLS	1. 1. Aware that greenhouse heating can be done by using geothermal energy sources, especially in cold climate zones. 2. Know that the most common form of application is provided by underground or floor heating. 3. Can list the leading countries in geothermal greenhouse cultivation in the world. 4. Know that greenhouse heating with geothermal energy sources has increased in Europe in recent years. 5. Aware of the existence of support for the use of geothermal resources in development programs. 6. Know the legislation on the use of geothermal resources, can adapt them to greenhouse activities.
C	KNOWLEDGE	1. Gain knowledge about the points to be considered in the installation of a geothermal greenhouse. 2. Gain knowledge about gothic greenhouses. 3. Have information about the ventilation systems of geothermal greenhouses. 4. Gain knowledge about foundation and side curtain concretes. 5. Have knowledge about the use of thermal curtain systems. 6. Gain knowledge about the plant growing environment in geothermal greenhouses. 7. Gain knowledge about irrigation systems in geothermal greenhouses. 8. Gain knowledge about the heating system in geothermal greenhouses.

	SKILLS	1. Know that geothermal greenhouses should be minimum 20.000 m2. 2. Know that especially soilless agriculture is done and he is aware that continuous automation systems should be followed. 3. Know to prefer gothic greenhouse type in geothermal greenhouse cultivation. 4. Can choose the ventilation system. He knows that fly net should be used. 5. Know how to use coconut shell in soilless agriculture. 6. Know automation irrigation systems and can choose the appropriate one. 7. Know the heating systems and has a good command of the techniques and principles in geothermal heating. 8. Have knowledge about heating systems, which are mostly in the form of ground and soil heating in geothermal greenhouse cultivation.
D	KNOWLEDGE	1. Gain knowledge about the advantages of geothermal greenhouses compared to traditional greenhouses. 2. Gain knowledge about the disadvantages of geothermal greenhouses compared to traditional greenhouses.
	SKILLS	1. Know that greenhouses can be heated with geothermal source even at lower temperatures. 2. Evaluate as an alternative source in cold months. 3. Aware of the fact that it is an environmentally friendly, renewable fuel. 4. Know that geothermal greenhouses have higher installation costs than traditional greenhouses.

REMARKS ON PRACTICE

1. It should be ensured that every adult who wants to have competence understands the subject.
2. During the module, the subject should be reinforced by using question-answer method, brainstorming and narration methods.

ASSESSMENT AND EVALUATION:

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Erasmus+ KA204, Strategic Partnerships for Adult Education Project

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