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INVESTIGATION OF INSIDE CLIMATE PARAMETERS IN UNHEATED HIGH TUNNEL GREENHOUSE

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ABSTRACT

In Türkiye, greenhouses without regular heating typically begin cultivation in March due to ecological reasons. However, low temperatures that occasionally occur during these months negatively impact cultivation. This study aimed to monitor inside climate parameters in high-tunnel greenhouses and evaluate measures to be taken. To this end, inside and outside temperatures, relative humidity, dew point temperature, canopy surface temperature, water condensation on the canopy's inner surface, light intensity, solar radiation, and photosynthetic active radiation were measured in March in the high-tunnel greenhouse and evaluated for cultivation. Data logger measurements revealed outside temperature and relative humidity values ranging from −5.7 to 11.0 °C and 53.4% to 91% throughout the trial. Inside temperature and relative humidity values ranged from −4.7 to 27.7 °C and 52.4% to 85.9%. Considering the low temperatures and high relative humidity values encountered during these periods, heating and ventilation of greenhouses becomes essential. Otherwise, the cover surface temperatures will drop below the dew point, causing condensation. Depending on the difference between inside and outside temperatures, water condensing on the inner surface of the cover can reach up to 90.1 g/m²/h. Furthermore, this condensed water on the cover surface has been determined to promote fungal diseases and reflect 67% of the light intensity reaching the interior, 34% of solar radiation, and 40% of photosynthetically active radiation. Therefore, taking measures such as attention to heating and ventilation during these months and the use of antifog-added cover materials will be crucial for cultivation.

Keywords*: high tunnel, air conditioning, temperature, relative humidity, condensation*

INTRODUCTION

Greenhouses are controlled production facilities that can produce high quality and high yields in all seasons. Controlled environment agriculture in greenhouses is a promising solution to meet the growing food demand of the global population (Costantino et al., 2021). However, for optimum yield,

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environmental conditions must also be maintained at optimum levels (Çaylı and Baytorun, 2021). Proper control of inside greenhouse conditions increases high crop productivity (Costantino et al., 2021). Proper control of inside conditions allows each plant to reach its genetic potential, which increases the quality and especially the quantity of production (McCartney et al., 2018). Greenhouses, often constructed of translucent materials, allow sunlight to create a controlled environment for crop growth (Angioni et al., 2012). By properly regulating inside conditions, yields can be significantly increased compared to open-field cultivation (Jin et al., 2020). Lack of climate control in greenhouses results in an inadequate microclimate, which negatively impacts yield components and input use efficiency. Better control of the greenhouse environment can increase marketable yield and quality, as well as extend the growing season (Baille, 1999). These structures not only extend the growing season and protect plants from harsh weather conditions, but also protect them from pests, reducing losses (Narayanan et al., 2025). In plant production in greenhouses, it is necessary to keep the growth factors within the comfort limits desired by the plants with minimum energy and labor (Baytorun and Üstün, 2022). Because the effectiveness of greenhouses depends on various microclimate parameters such as solar radiation, temperature, humidity and CO_2 concentration (Benni et al., 2016). Greenhouse farms in Türkiye can be divided into two categories based on their technological use, structural condition, and size. These are small-scale family farms and modern farms where inside climate conditions are controlled (Tüzel et al., 2005). First, with limited technology use and high energy costs, heating plants to meet their optimum needs in these farms requires significant costs. Therefore, instead of regular heating to increase yields, these farms use heating to protect plants from frost. Failure to regularly heat can lead to lower yields, restrictions on production types, and the need to use hormones (Hazardın, 1994; Yağcıoğlu, 1999).

Despite high yields, the quality of greenhouse-grown produce has been the subject of significant debate both domestically and internationally in recent years. One of the primary factors contributing to quality problems is the climate parameters within the greenhouse. Low temperature and high humidity levels, on the one hand, lead to deficiencies in physical, chemical, and aromatic quality, while on the other, necessitate the intensive use of pesticides and hormones (Baytorun et al., 2013). Heating is a precautionary measure to overcome the problems of low temperature and high humidity in greenhouses. To achieve both high-quality and high-quality yields from greenhouses, heating should be provided when the average daily outside temperature falls below 12 °C (Nisen et al., 1988, von Zabeltitz, 2011). Air temperature can affect many plant processes. The optimum temperature for growth of most plants in greenhouses ranges from 17°C to 27°C, with extreme values between 10 °C and 35 °C (Benni et al., 2016). Thus, greenhouses can be heated or cooled to maintain a suitable internal air temperature level depending on the response to changing external climatic conditions (Ahamed et al., 2019; Choab et al., 2019). In unheated greenhouses, one of the problems caused by excessive temperature drops at night is moisture condensation, which occurs on the inner surface of the greenhouse cover and on the plant surface. This moisture condensation not only damages the greenhouse framework but also increases the risk of plant disease. Moisture condensation, which begins at night, often continues for some time after sunrise. This negatively affects the light transmittance of the cover material (Çolak, 2002). A key property of cover materials relates to their condensation properties.

A serious problem with cover materials is the formation of droplets of condensation on the inner surface of the materials. These water droplets can produce a number of undesirable effects. They reduce solar radiation transmission due to total internal reflection of incoming solar radiation and, when small droplets merge into larger ones, cause dripping onto plant surfaces, promoting plant diseases (Geoola et al., 2004). In greenhouse cultivation, when outside temperatures are low, adapting the inside climate to plant growth is quite challenging. The high heat and energy requirements during these months, coupled with the resulting high relative humidity, necessitate heating or ventilation to prevent negatively impacting plant growth. While this may result in energy loss, lack of ventilation will lead to disease formation due to water droplets condensing on the inside cover material and plant surfaces. This can lead to the emergence of significant plant diseases and yield losses during cultivation.

In the study, the suitability of inside climate parameters for plant cultivation was investigated by measuring the temperature, relative humidity, dew point temperature, light intensity, solar radiation and photosynthetic active radiation values in an unheated high tunnel greenhouse.

MATERIALS AND METHODS

In the study used a high tunnel greenhouse with a 3x5 m floor area and a 2 m height covered with UV+IR additives and a PE material. The ratio of ventilation openings to the floor area of the high tunnel is 15%. Temperature (°C) and relative humidity (%) were measured outside and inside the tunnel using On-Set HOBO U12 data loggers, while light intensity (lux), solar radiation (W/m^2) and photosynthetic active radiation (PAR) ($\mu mol/m^2$ h) were measured at 30-minute intervals using an Apogee pyranometer sensor.

In the study, the day was divided into three parts: daily measurement averages (all day), daytime (radiation present), and nighttime (no radiation). During the trial, sunrise and sunset occurred approximately between 07:30 and 18:30.

The calculation of the inner surface temperature of the cover was made with the help of Equation 1 and Equation 2 (Tantau, 2013; Baytorun et al., 2018):

$$Q_{si} = (R_\lambda + R_e) \times U \times (Q_i - Q_e) + Q_e \tag{1}$$

$$R_\lambda = U^{-1} - R_i - R_e \tag{2}$$

where;

- Q_{si} – Inner surface temperature (°C)
- R_λ – Heat conduction resistance of the cover material (m^2°C/W)
- R_e – External surface thermal conduction resistance of the cover material (m^2°C/W)
- U – Heat transfer coefficient (7 W/m^2°C)
- Q_i, Q_e= Inside and External temperature difference (°C)

The amount of water (C_o) condensed on the inner surface of the cover material was calculated by Equation 3 (Tantau, 2013):

$$C_o = h_{ic} \times \frac{(\theta_i - \theta_{si})}{r_o} \times 3600 \quad (3)$$

where;

- C_o= Quantity of condensation (g/m^{2}h)
- h_{ic}= Heat transfer coefficient of the cover inner surface for condensation (W/m^2°C)
- r_o= Enthalpy of evaporation of water (j/kg)

RESULTS AND DISCUSSION

Determination of Temperature and Relative Humidity Changes

In Türkiye, March is the planting season for crops in regions where greenhouse cultivation is carried out based on ecological factors. During this spring month, low outside temperatures can negatively impact inside plant cultivation. Therefore, monitoring inside climate parameters and taking necessary precautions for cultivation are crucial. For this purpose, daytime, nighttime, and daily data for temperature and relative humidity measurements taken with data loggers in the tunnel greenhouse during the trial are presented in Table 1.

Table 1. Temperature and relative humidity values measured in inside and outside environments

Location	Measurement	Temperature [°C]			Relative humidity [%]		
		Min.	Mean	Max.	Min.	Mean	Max.
Inside	Daytime	−4.5	13.3	27.7	52.4	72.0	85.9
	Night	−4.7	1.8	11.1	71.2	83.6	85.9
	Daily	−4.7	7.2	27.7	52.4	78.1	85.9
Outside	Daytime	−5.0	3.1	11.0	53.4	71.8	89.5
	Night	−5.7	0.4	7.2	68.4	81.9	91.0
	Daily	−5.7	1.7	11.0	53.4	77.1	91.0

Table 1 shows that during the trial, daily outside temperature values were measured between −5.7°C and 11.0 °C, with an average of 1.7 °C. Inside temperature values were measured between –4.7 °C and 27.7°C, with an average of 7.2 °C. During the trial, outside relative humidity values were measured between 53.4% and 91.0%, with an average of 77.1%. Inside relative humidity values were measured between 52.4% and 85.9%, with an average of 78.1%.

The change between outside-inside temperature and relative humidity values during the trial is given in Figure 1, and the relationship between outside and inside temperature and relative humidity is given in Figure 2.

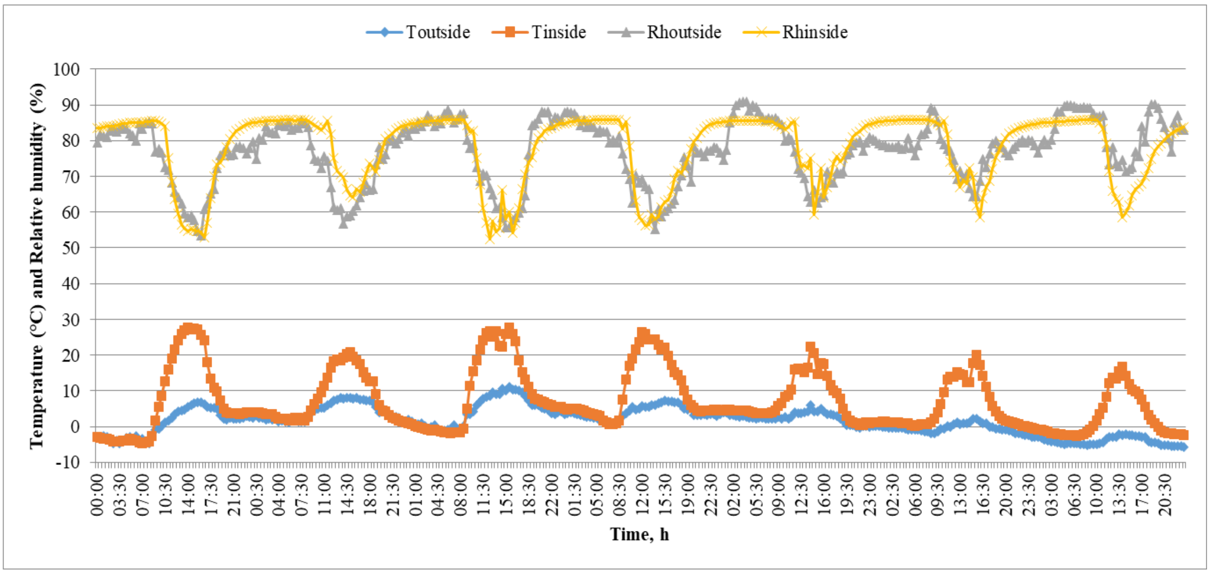
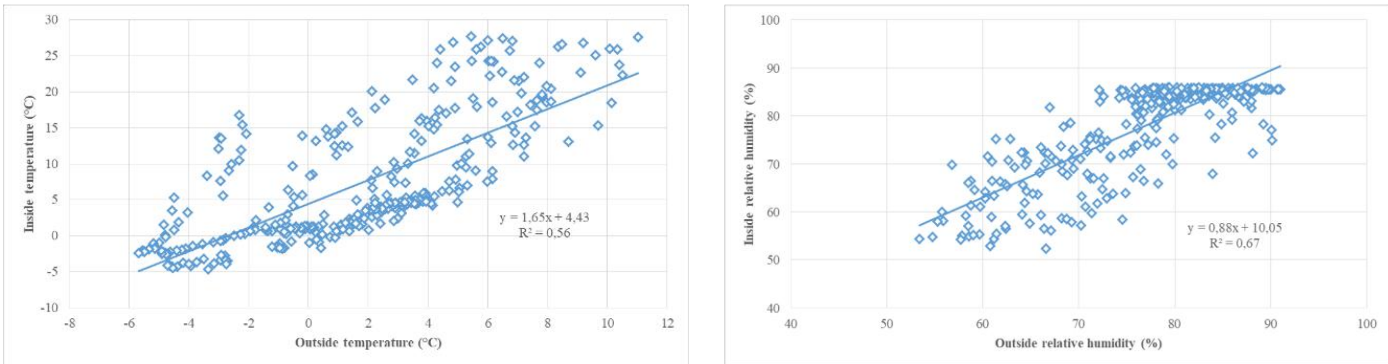


Figure 1. Changes between outside-inside temperature and relative humidity values.



A B

Figure 2. Relationship between (A) outside-inside temperature values and (B) outside-inside relative humidity values.

In the unheated tunnel greenhouse, inside temperatures increased due to solar radiation reaching the interior. The infrared (IR) additive used in the cover material also contributed to heat retention in the interior. At the same time, increasing inside temperatures with sunrise caused a decrease in relative humidity within the tunnel (Figure 1). The relationships between outside and inside temperature values (R^2=0.56) and outside-inside relative humidity values (R^2=0.66) within the tunnel greenhouse were found to be weak (Figure 2).

The study found that between 00:00 and 07:30, outside temperatures reached lower than outside temperatures due to the inversion that occurs during clear daylight hours in the greenhouse. The biggest problem with plastic greenhouses is that polyethylene plastic transmits infrared rays within a certain bandwidth (von Zabeltitz, 2011). This causes greenhouse interior temperatures to drop below outside temperatures, particularly under clear sky conditions. Plants are adapted to temperatures between 17°C and 27 °C during the growing season. Optimum temperatures range from 15-20 °C at night and 22-28 °C during the day (Castilla and Hernandez, 2007). Baytorun et al. (1999) reported that the minimum average temperature in an unheated greenhouse covered with plastic sheeting was maintained at 8.2°C during the December-February period, yielding 19 kg/m^2. During the same period, the minimum average temperature was maintained at 11.5°C, yielding 24 kg/m^2. It is known that low or high temperatures in greenhouses negatively affect plant growth. Relative humidity is also an important greenhouse climate variable. High relative humidity can cause condensation on plant surfaces and increase the proliferation of pathogenic fungi. When high relative humidity in greenhouses decreases, the likelihood of pathogen-induced infection also decreases (Yunis et al., 1990; Elad et al., 1996). According to reports by Körner and Challa (2003), humidity control is crucial for achieving high, quality yields. Without humidity control, high relative humidity levels can lead to losses in product quality due to fungal diseases, leaf necrosis, calcium deficiencies, and soft and thin leaves. High humidity conditions can also inhibit pollination in fruit and vegetables because pollen grains tend to remain in the interior or adhere to anthers (Bakker, 1991; Kranz, 1996). In this study found that the low inside temperatures and high relative humidity values that occur after sunset in unheated and ventilated tunnel greenhouses are unsuitable for plant growth. Heating should be provided during these periods, especially when outside temperatures are higher than inside temperatures, to protect plants from frost. Furthermore, the high relative humidity resulting from unventilated inside environments is highly likely to lead to yield losses and disease.

Dew Point Temperature and Quantity of Condensation

Moisture condenses on any surface whose temperature is below the dew point of the surrounding air. The dew point temperature, surface temperature, and the amount of water condensed on the inner surface of the cover material are given in Table 2.

Table 2. Dew point temperature, surface temperature and amount of water condensed on the inner surface of the cover material.

Location	Measurement	Dew point temperature [°C]			Inner surface temperature [°C]			Quantity of condensation [g/m^2/h]		
		Min.	Mean	Max.	Min.	Mean	Max.	Min.	Mean	Max.
Inside	Day	−6.6	8.1	19.1	−4.8	3.9	12.4	−3.0	41.3	90.1
	Night	−6.8	−0.7	6.6	−5.4	0.5	7.5	−8.5	5.4	25.1
	Daily	−6.8	3.4	19.1	−5.4	2.1	12.4	−8.5	22.3	90.1

According to the obtained data, dew point temperatures inside the greenhouse varied between −6.8 °C and 19.1 °C. The interior surface temperatures of the cover material were determined to be -5.4 °C and 12.4 °C, and the condensed water amount was determined to be −8.5 to 90.1 g/m^2/h (Table 2). Here, negative values for the condensed water amount represent hours when inside temperatures are lower than outside temperatures due to inversion. Additionally, decreasing inside-outside temperature differences at night reduced dew point temperatures. Increasing inside-outside temperature differences, especially at noon, increased dew point temperatures but also increased the amount of condensed water. In greenhouses where thermal curtains are not used, the surface temperature of the cover reaches the dew point due to the outside temperature, reducing humidity in the greenhouse due to condensation on the cover surface (von Zabeltitz, 2011). Similarly, in this study, inside relative humidity values decreased due to increased condensation at noon and increased at night. The changes in dew point temperature, cover surface temperature, and the amount of water condensed on the cover's inner surface are shown in Figure 3.

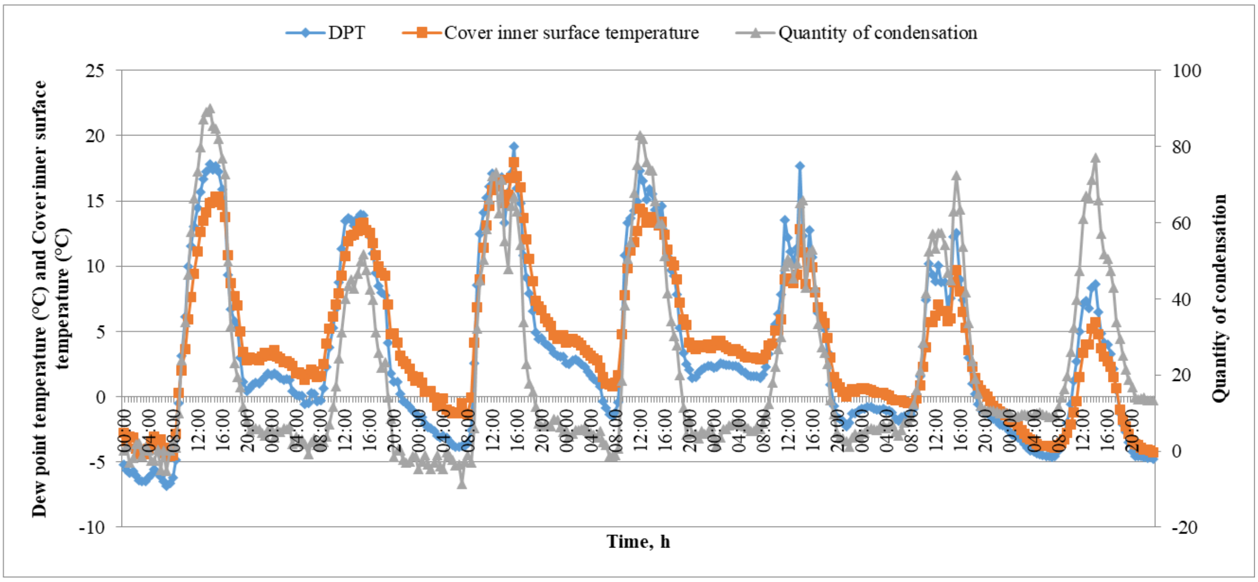


Figure 3. Changes in dew point temperature, cover inner surface temperature and condensed water amount.

Plant transpiration and soil evaporation produce water vapor, which, if not removed from the greenhouse air, will condense on surfaces with temperatures lower than the dew point (Katsoulas et al., 2021). Figure 3 shows that condensation begins on the inner surface of the cover material between 09:30 and 18:30. Increased radiation levels during these hours caused inside temperatures to rise due to the greenhouse effect. The difference between inside and outside temperatures during these hours increased, causing moisture condensation on the cover material surface. This is an undesirable situation because condensed water droplets on the inner surface of the cover drip onto the plants, potentially causing disease. Dew in unheated greenhouses causes fungal diseases to develop rapidly (Çolak, 2002). Surface-active additives are necessary to prevent condensed droplets from reaching the plant surface. On such materials, condensation spreads evenly across the surface, causing the condensation to flow rather than forming droplets (Geoola et al., 2004). Therefore, it has been determined that condensation on the inner surface of a tunnel greenhouse without ventilation during the day will negatively impact plant growth. Failure to ventilate to increase inside temperatures will cause fungal diseases in plants due to condensation, leading to increased yield losses. In addition to heating and ventilation during these periods, the use of anti-fog-added covering material is also important to prevent droplets from falling on the plants.

Determining changes in light intensity, solar radiation and photosynthetic active radiation values

The light intensity, solar radiation and photosynthetic active radiation values measured in the study are given in Table 3.

Table 3. Light intensity, solar radiation and photosynthetic active radiation values.

Location	Measurement	Light intensity [Lux]			Solar radiation [W/m²]			PAR [μmol/m²·s]		
		Min.	Mean	Max.	Min.	Mean	Max.	Min.	Mean	Max.
Inside	Day	11.8	290.1	871.2	2.4	192.1	649.5	215.0	701.8	1224.0
	Night	11.8	12.0	19.7	0.0	0.0	0.0	47.2	118.6	608.8
	Daily	11.8	142.8	871.2	0.0	90.3	649.5	47.2	392.9	1224.0
Outside	Day	3.9	918.3	3543.8	2.4	290.5	828.9	346.0	1129.3	1965.9
	Night	3.9	3.9	11.8	0.0	0.0	0.0	85.0	227.7	949.5
	Daily	3.9	433.9	3543.8	0.0	136.6	828.9	85.0	654.7	1965.9

The daily changes in the light intensity values between the inside and outside of the high tunnel are shown in Figure 4.

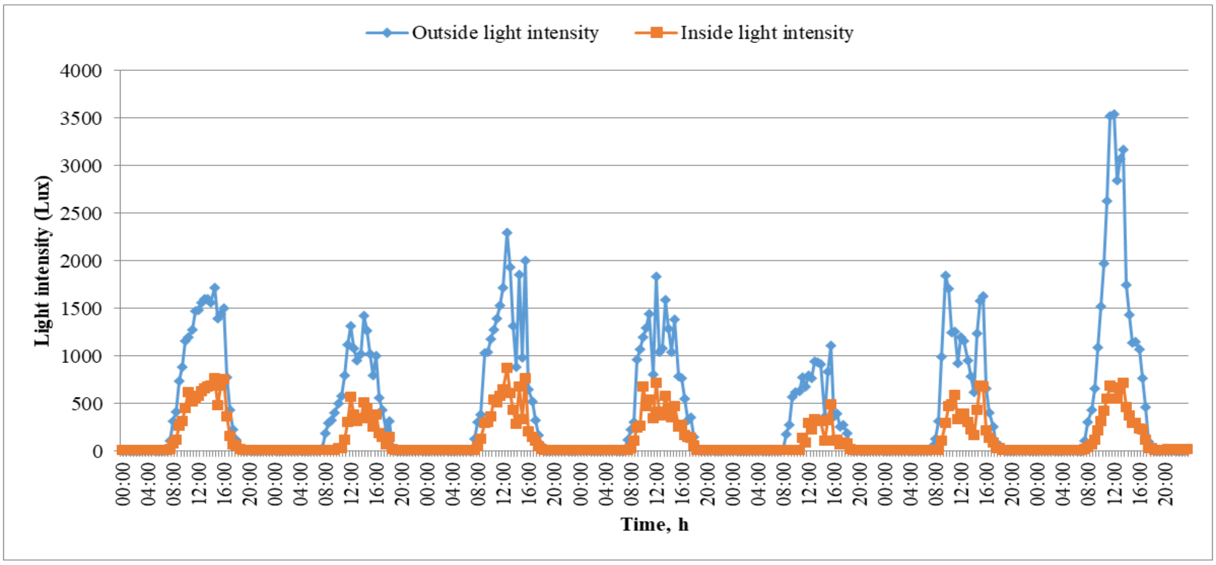


Figure 4. Changes in light intensity values.

The daily, daytime, and nighttime average light intensity measured outsides was 433.9, 918.3, and 3.9 Lux, respectively. The daily, daytime, and nighttime average light intensity measured inside was 142.8, 290.1, and 12 Lux, respectively (Table 3). Accordingly, the light intensity reaching the interior decreased by 67% compared to the exterior. In the study, although the light intensity in the outside environment was high at noon hours, the light intensity reaching the inside environment decreased due to the cover material and the condensation on the cover material (Figure 4). This is because the condensation on the inner surface of the cover at noon hours blocked the light reaching the inside environment and reflected it back.

The relationship between inside and outside light intensity of the high tunnel is shown in Figure 5.

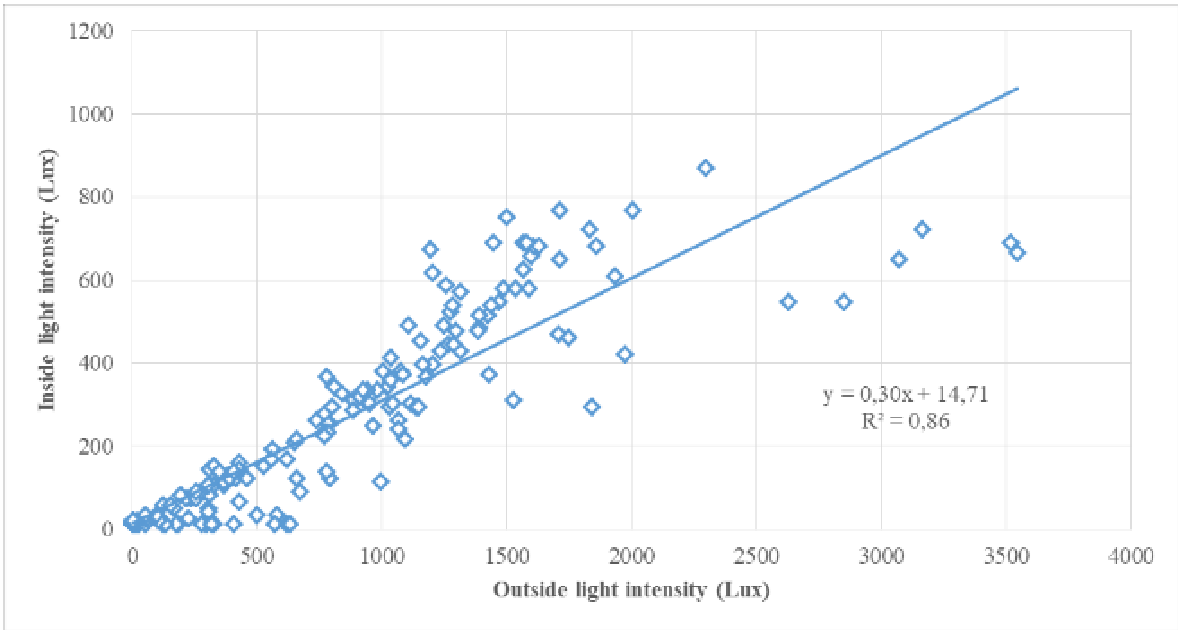


Figure 5. Relationship between inside and outside light intensity values.

An important correlation (R^2=0.86) was found between inside and outside light intensity. This suggests that increasing or decreasing outside light intensity also affects inside values. Furthermore, ventilation or heating is necessary, especially during midday hours, to allow water droplets condensing on the roof surface to pass through the incoming light.

Optimum light levels must be maintained for cultivated plants. Low light slows growth and increases production costs. Therefore, it is crucial to increase light levels by minimizing the shading effects of greenhouse frame materials, heating pipes, and other equipment on plants (Parker 1999). Susaj et al. (2020) measured the light intensity outsides as 37098.4 Lux, the average light intensity in the large greenhouse as 14367 Lux, and the average light intensity in the small greenhouse as 1574 Lux. Accordingly, the light intensity in the large greenhouse was 38.7% of the outside light intensity and 4.25% in the small greenhouse. The light intensity in the small greenhouse was approximately 10.95% of the large greenhouse. The study determined that only 33% of the light reaching the interior was due to condensation occurring on the interior surface of the cover during daylight hours, reducing light intensity. Ventilation during these hours is crucial to increase the amount of light reaching the interior. However, the general consensus among growers is that ventilation during these hours will reduce inside temperatures. However, this will negatively impact yield by reducing incoming light.

The changes in solar radiation values in the high tunnel throughout the day are shown in Figure 6.

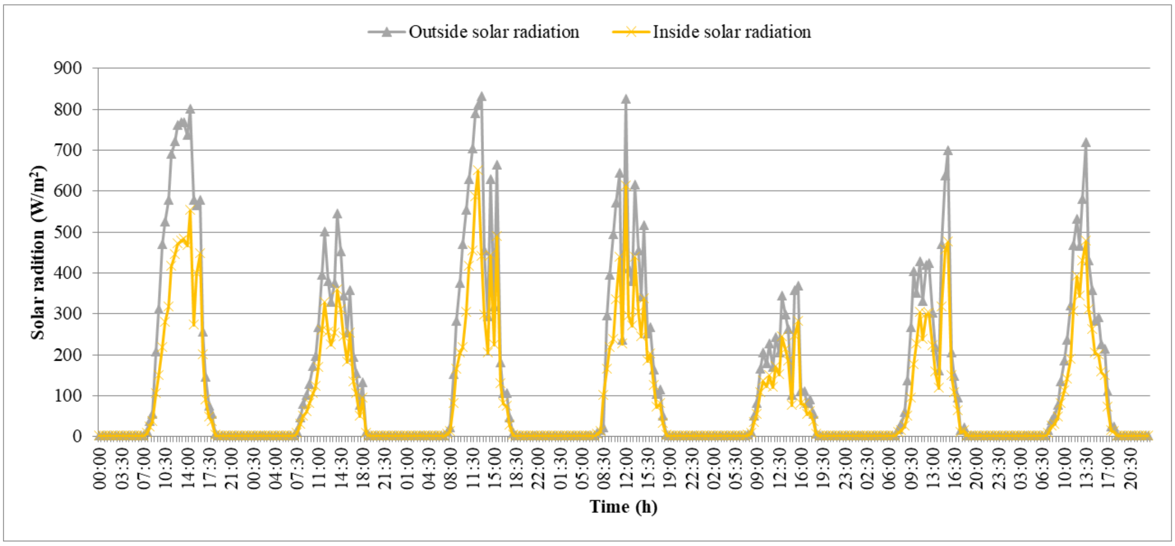


Figure 6. Changes in inside and outside solar radiation values.

The daily, daytime, and nighttime average solar radiation measured outside was 136.6, 290.5, and 0 Watt/m², respectively. The daily, daytime, and nighttime average light intensity measured inside was 90.3, 192.1, and 0 Watt/m², respectively (Table 3). Accordingly, solar radiation reaching the interior decreased by 34% compared to the exterior. In the study, solar radiation values decreased, as did the light intensity reaching the interior environment, due to the covering material used in the greenhouse and the condensation on the covering material (Figure 6). This decrease was proportionally less than the light intensity.

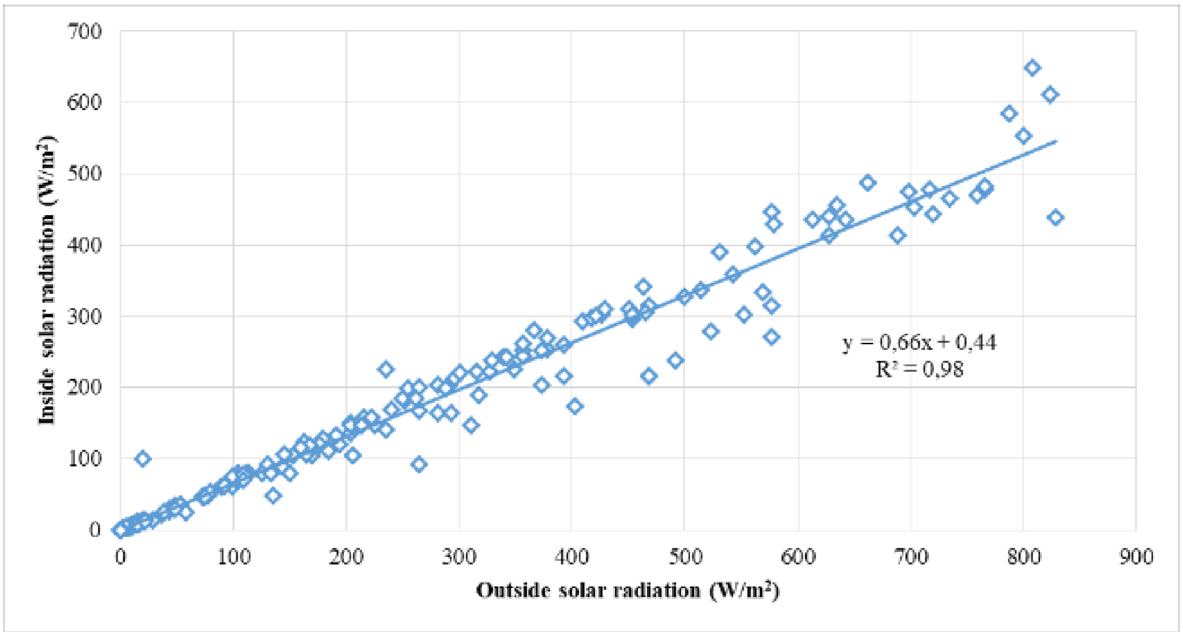


Figure 7. Relationship between inside and outside solar radiation values.

An important correlation (R^2=0.98) was determined between inside and outside solar radiation (Figure 7). Accordingly, increasing or decreasing outside radiation levels also affects inside values. Increasing incoming radiation levels will increase inside temperatures, contributing to increased efficiency. Therefore, it is crucial to take precautions to prevent condensation during the hours between sunrise and sunset.

Solar radiation is the most important factor affecting plant growth, and photosynthesis is the most important process governing plant growth. Therefore, the properties of greenhouse covering materials, which can affect the level and quality of transmitted radiation, are of primary importance for greenhouse cultivation (Geoola et al., 2004). High relative humidity in unheated greenhouses not only leads to disease but also condenses on the inner surface of the covering material, reducing solar radiation reaching the greenhouse by 15% (Baytorun et al., 1994). In the study conducted by Papadakis et al., (2000), it was stated that the radiation transmittance of single layer polyethylene films varied between 70-95%. Pollet et al. (2001) reported that the total amount of radiation transmitted in a greenhouse covered with polyethylene plastic sheeting was reduced by 22-23% due to condensation droplets. They also reported that the photosynthetic rate was 16% higher under dry polyethylene compared to dry glass due to the scattering properties of the plastic film. In the presence of dew, the photosynthetic rate was 13% higher under single-pane glass and a 6% decrease under polyethylene compared to dry glass and polyethylene. Tezcan (2022) determined the radiation values reaching the outside and inside environments in the greenhouse using polyethylene cover material as 402.6 Watt/m² and 321.7 Watt/m² (80%) in October, 340.4 Watt/m² and 266.8 Watt/m² (78%) in November, and 275 Watt/m² and 156.9 Watt/m² (57%) in December, respectively. The study reported that increasing the cover thickness and the additives used reduced the radiation value. In this study, the radiation rate reaching the inside environment was lower than the researchers' values due to the lack of heating and ventilation in the high tunnel.

The changes in PAR values in the high tunnel throughout the day are shown in Figure 8.

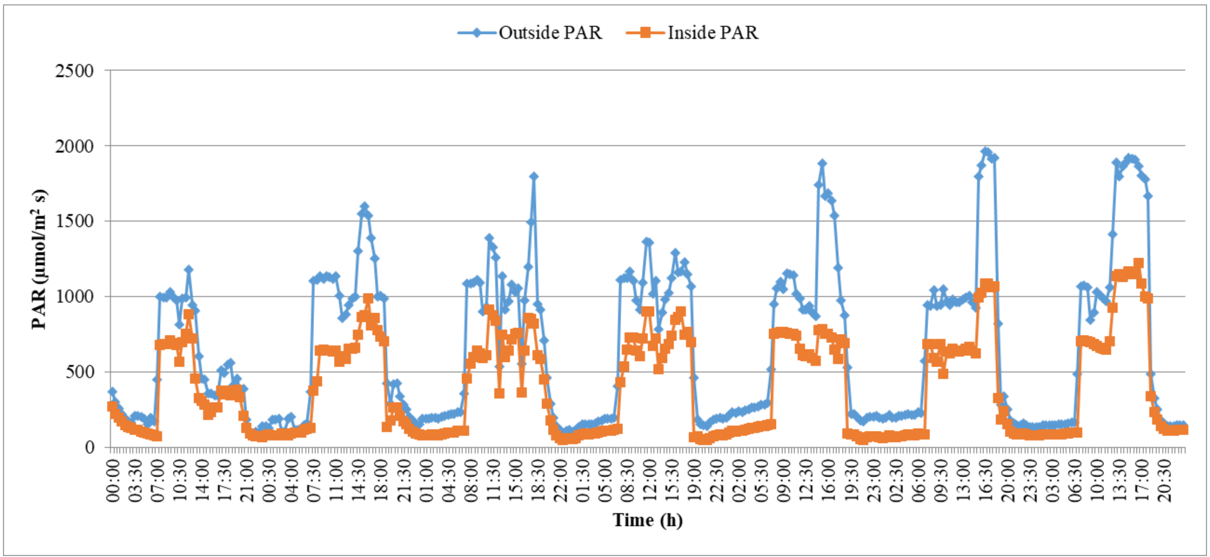


Figure 8. Changes in inside and outside PAR values.

Daily, daytime, and nighttime average PAR values measured outsides were 1133, 1168.4, and 1103.9 µmol/m^2 s, respectively. Daily, daytime, and nighttime average PAR values measured insides were 741.3, 763.6, and

721.5 µmol/m^2 s, respectively (Table 3 and Figure 8). Accordingly, the PAR reaching the interior decreased by 40% compared to the exterior.

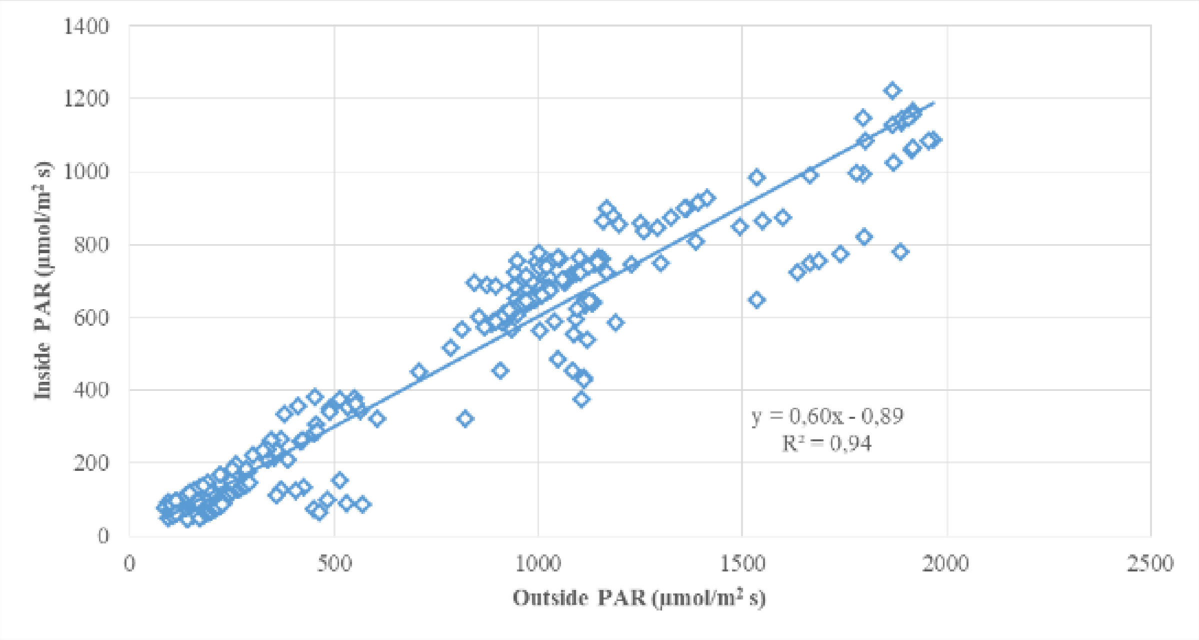


Figure 9. Relationship between inside and outside solar radiation values.

An important correlation (R^2=0.94) was determined between inside and outside PAR (Figure 9). Accordingly, increasing or decreasing outside PAR levels also affects inside values. Increasing incoming PAR levels will increase inside temperatures, contributing to increased efficiency. Therefore, it is crucial to take precautions to prevent condensation during the hours between sunrise and sunset.

Plants require light throughout their life cycle, from germination and growth to flowering and seed production (Singh et al., 2015). Solar radiation (sunlight) provides the primary light source for plants. However, plants do not absorb all wavelengths of solar radiation. Solar radiation in the 400–700 nm spectrum, known as photosynthetically active radiation (PAR), is responsible for the photosynthesis process, which is essential for plant growth (Ciolkosz, 2008; Iddio et al., 2020). In greenhouses, PAR availability has been widely used as an indicator to justify the essential condition of maintaining a normal growth for plants in greenhouses (Klaring et al., 2012; Singh et al., 2015). Di Mola et al. (2022) measured the PAR concentration in the greenhouse using the additive cover material at 2:00 p.m. at 529 µmol/m² s, approximately 36.3% lower than that inside the control greenhouse (1459 µmol/m² s). At the same time, the PAR concentration under direct sunlight was 2042 µmol/m² s. Tezcan (2022) determined the PAR values reaching the outside and inside environments in the greenhouse using additive polyethylene cover material as 348.6 and 248 (71%) in October, 287.5 and 196.3 (68%) in November, and 206.3 and 121.6 (59%) in December, respectively. And also reported that increasing the cover thickness and the additives used reduced the PAR value.

In protected cultivation, the solar energy distribution is divided into three fractions: one part is reflected, another is absorbed, and the third is transmitted (Rebouças et al., 2015). Such light diffusion is influenced by structural factors of the environment, such as the type of material, used for cultivation and internal factors such as the reflectance of solar radiation by the vessels and supports inside (Von Zabeltitz, 2011; Costa et al., 2020). Accordingly, when examining external and internal light intensity, solar radiation, and PAR values, it was determined that an average of 33% of the light intensity reaching the outside environment reaches the inside environment, while an average of 66% of the external radiation and an average of 60% of the PAR values are transmitted to the greenhouse interior. This is due to the covering material reflecting some of the incident light intensity and radiation, moisture condensing on the inside surface of the covering, and the shading effect of snowfall occurring outside on certain days and hours. Tezcan (2002) reported that the properties of the covering material are important, considering the decreasing solar angle, decreasing temperatures, and the use of heating in greenhouses for frost protection during the months of October, November, and December in Turkey. Accordingly, the covering material used in greenhouses should contain anti-fog additives to prevent condensed water droplets from falling onto the plant. Otherwise, condensed droplets could cause disease and reduce the radiant energy reaching the inside environment, thus decreasing inside temperatures. Furthermore, by reducing the amount of light required for photosynthesis, it would lead to yield losses.

CONCLUSION

In modern greenhouses in Turkey, inside climate parameters can be controlled year-round, while small-scale family farms focus on ecological cultivation. High energy costs currently limit the ability of these businesses to implement measures such as heating, cooling, and ventilation. The production season for these businesses begins in March. However, low outside temperatures, which occur on certain days during this month, negatively impact inside climate. Accordingly, the study determined that when planting seedlings in Türkiye begins in early March, attention should be paid to the periodic low outside temperatures. Seedlings will be affected by these low temperatures, particularly during morning inversions when inside temperatures are lower than outside temperatures. Furthermore, the resulting high humidity will cause condensation on the cover surfaces. This condensation will drip onto the plants, contributing to disease, and will significantly reduce the amount of light reaching the inside environment, affecting the plants' photosynthesis rate. Some of the measures to prevent adverse effects occurring during these months are as follows. Measures such as heating the interior during periods of low temperature, ventilation especially at noon, and using thermal curtains or double layers of cover material on the side walls to increase the interior surface temperature of the cover are very important in reducing yield losses in cultivation.

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