INFRASTRUKTURA I EKOLOGIA TERENÓW WIEJSKICH
INFRASTRUCTURE AND ECOLOGY OF RURAL AREAS

No III/1/2019, POLISH ACADEMY OF SCIENCES, Cracow Branch, pp. 197-217
Commission of Technical Rural Infrastructure

DOI: https://doi.org/10.14597/INFRAECO.2019.3.1.015

DETERMINATION OF THE EFFECT OF INSECT NET USED IN GREENHOUSE ON INDOOR CONDITIONS: PEPPER PLANT SAMPLE

Aytekin Ocak, Atılgan Atilgan
Isparta University of Applied Sciences

Abstract

The aim of this study is to determine the effects of insect net placed on ventilation openings in greenhouses on temperature, humidity and radiation energy from indoor conditions. In addition, the effects of insect net on the agents used in biological control have been tried to be determined. The study was carried out between November 2017 and May 2018 in Kumluca district of Antalya in 2 glass and 2 plastic greenhouses. Greenhouses; the glass greenhouse without insect net (GCG), the glass greenhouse with insect net (GNG), the plastic greenhouse without insect net (PCG), the plastic greenhouse with insect net (PNG) is named as. Temperature, humidity and solar radiation values were measured in greenhouses. According to the results of the research; It was determined that the recommended temperature values for pepper development are only suitable in January and well below the recommended values in February. In other production months, the average temperature values of with insect net greenhouses (PNG-GNG) used in ventilation openings were found to be higher than without insect net greenhouses (PCG-GCG). When the results of relative humidity values were examined, it was observed that the use of insect tulle in the greenhouses was lower than the control greenhouses. It was determined that the solar radiation values were lower than the control greenhouses (PCG-GCG) of the insect tulle greenhouses (PNG-GNG) in other months except January and May. Therefore, we can say that the use of insect net reduces the amount of solar radiation. According to the results of temperature values; the growth of *Orius Leavigatus* and *Amblyseius swirski*, one of the biological agents and resistant to high temperatures, was observed to slow down in all other months except February. For *Phytoseiulus persimilis* (30^{o}C and above), we can say that this is a suitable environment and that the eggs have emerged in a shorter time. The most suitable average temperature for the development of *Aphidius colemani* was reached only in January. In other months, the development of this agent slows down, parasitic insecticides can be said to decrease the rate of parasitoids. As a result; It was determined that the temperature values were higher in the greenhouses where insect net was used and the solar radiation values were lower than the control greenhouses. However, since the use of insect net causes the temperature in the greenhouse to increase, it may create a positive development for some bio agents. It is thought that producers using insect net should make production considering these negativities in temperature and solar radiation.

Keywords: Insect net, Solar Radiation, Temperature, Greenhouse

INTRODUCTION

Food requirements and thus agricultural production of countries should be made more efficient taking into consideration the population increase in order for countries to continue their presence in the future. The rapid increase of population in our country coupled with the continuous decrease of agricultural areas has made it necessary for the farmers to take precautions for increasing the yield per unit area. The use of new technology and agricultural methods are among the primary precautions that should be taken. Improvement of vegetable and fruit production and especially increasing greenhouse cultivation has become a necessity (Güllüler, 2007). The total greenhouse area in our country based on 2018 TUIK data is 77 209,10 hectares with a vegetable production of 7 535 511 tons. Pepper makes up 689 169 tons of this production (TUİK, 2019). Pepper is a hot and temperate climate vegetable. Optimal development of pepper depends on temperature, partially to light intensity as well as the humidity of the soil and the air. It grows well especially when soil humidity is high, soil has sufficient nutrients and temperature is around 24-26ºC. Pepper plant loves light and can show a good development at a light time of 12 hours of the day (Aktas et al., 2003)

Biological control is the suppression of pesticide populations by their natural enemies. This term was first used in 1919 by Smith. Biological control emerged as a result of the biological, ecological and systematic examination of the relationships between living things in nature (Uygun et al., 2010). It is known that the use of Biological Control agents has increased recently in greenhouses at the city of Antalya and its districts. An insect net with 40-60 mesh clearance is used at the side ventilations for preventing the entry of pests. The impact of the insect net placed on ventilation clearances on climate data inside the greenhouse is not known. The impact of these data on the development of pepper and biological control agents is not known. It is indicated that the air entering the greenhouses at certain intervals from side and top ventilations plays an important role in the development of Plants and Biological Control Agents. The aim of the present study was to determine the effectiveness of the insect net placed on ventilation clearances on temperature, humidity and radiation energy and to determine the extent at which the agents used for biological control are affected.

MATERIAL AND METHOD

The study was carried out at a total of 4 greenhouses with 2 plastic and 2 glass greenhouses at the Kumluca district of the city of Antalya. The technical characteristics of the greenhouses selected as material in the study are presented in Table 1. As can be seen in the table, GNG denotes the glass greenhouse with insect net, GCG the glass greenhouse without insect net, PNG the plastic greenhouse with insect net and PCG the plastic greenhouse without insect net. Greenhouses with similar dimensions were determined as a result of discussions with the producers prior to the study.

Table 1. General information about the greenhouses

Greenhouse type	Cover Type	Greenhouse Dimensions (m)				Greenhouse Direction
		Width	Length	Height		
				Wall	Ridge	
GNG (the glass greenhouse with insect net)	Glass	18	105	1,5	9	N-S
GCG (the glass greenhouse without insect net)	Glass	18	105	1,5	9	N-S
PNG (the plastic greenhouse with insect net)	Plastic	22	77,5	3	4,15	N-S
PCG (the plastic greenhouse without insect net)	Plastic	20	75	2,5	3,50	N-S

The study started on November 15, 2017 and ended on May 31, 2018. Measurements were taken at certain days of the month throughout the duration of the study taking into consideration the development period of pepper. However, the dates indicated in Table 2 were used to prepare and interpret the graphs in order to monitor the development values of pepper and Bio Agents. Table 2 was prepared in accordance with the dates indicated by the producers in the region regarding the implementation of pepper plant cultivation activities. The dates at which values such as temperature, solar radiation and humidity were measured during the experiment were determined by taking into consideration the criteria such as the first side shoot and fruit formation of the pepper plant, first harvest, vegetative growth and pruning and final harvest etc. Temperature, humidity and solar radiation measurements were carried out in the greenhouse. Greenhouse interior solar radiation values were using PCE-SPM 1 solar radiation measurement device. Temperature and humidity values for the greenhouse were measured throughout the experiment using Testo 175 H1 brand hygrometer. Special attention was given to the replacement of the batteries of the solar radiation devices and solar power meters were installed at an elevation of 1,5 m above ground to prevent the impact of shading on plants (Figure 1).

Insect net; It provides protection against trips, tuta absoluta and other harmful insects, flies and worms. 40 mesh insect net was placed in the ventilation openings in both glass and plastic greenhouses. The most important feature of insect net is to prevent the entry of harmful insects, virus and birds into the greenhouse (Mahmood et al., 2018) and to prevent the release of parasitoids and predators out of the greenhouse (Anonymous, 2019a, Ocak. 2019). Insect net was placed along the ventilation opening (1.6 height x 105 length) of the GNG as well as the opening (1.7 height x 77.5 length) of the PNG.

Table 2. Days in which the measured values are interpreted in the study.

Development Periods of Pepper Plant and Bio Agents	Date	Measurement Time
First side shoot formation of pepper and first application of Bio Agents	15 November 2017	10.00-16.00
The first harvest period of pepper and development of Bio Agents	15 December 2017	10.00-16.00
Development of Pepper and Bio Agents	15 January 2018	10.00-16.00
Development of Pepper and Bio Agents	15 February 2018	10.00-16.00
Lower Leaf Pruning of Pepper and Development of Bio Agents	15 April 2018	10.00-16.00
Last harvest period of pepper plant and development of bio agents	15 May 2018	10.00-16.00

Solar radiation measurement device took measurements at intervals of 1 min., temperature and hygrometer took measurements at intervals of 1 hour. The values measured between 10.00 am in the morning and 16.00 in the afternoon each day were used in the study to prepare the graphs that evaluate each greenhouse together. T-test was applied in order to interpret the differences between the acquired data. T test is the most frequently used test among the hypotheses tests. It can be defined as an approach that tries to determine whether there are any statistically significant differences between the averages of two groups of data. It is also known as small sample trial method. The reason for this is that it is a statistics method that can be applied in cases when n<30 or when there are suspicions with regard to the universe average being normal (Akça, 2013).

Figure 1. View of sensors in the greenhouse

RESULTS AND DISCUSSIONS

Temperature, humidity and solar radiation values were started to be measured in a controlled manner with the start of the study. Therefore, data for November 15, December 15, January 16, February 16, March 11, April 7 and May 11 after the start of production were measured at PNG, PCG, GNG and GCG greenhouses. Greenhouse ambient temperature, humidity and solar radiation values were measured and compared for PNG-PCG and GNG-GCG greenhouses. The daytime temperature required for pepper growth is 22-25 ºC (Salk et al., 2008), whereas the night-time temperature is 15-17 ºC (MEGEP, 2008). The relative humidity required for pepper in greenhouses is around 70-80% (MEGEP, 2008). Greenhouse internal radiation values were interpreted using visual graphs for the aforementioned dates starting from 10 am to 4 pm on different days of the months of November, December, January, February, March, April and May in order to determine the solar energies for the greenhouses included in the study. The month of November is the period at which the first side shoot of pepper plant develops and the bio-agents are applied to the greenhouse for the first time. The temperature requirement for proper pepper growth during this period is 22-25^oC, whereas the humidity requirement is 70-80 %. Figure 2 presents the temperature, humidity and radiation energy values for 4 different greenhouses at which measurements were carried out on November 15. Accordingly, highest greenhouse average temperature was measured at GNG from among glass greenhouses (36,56^oC) and at PNG (32,94^oC) from among plastic greenhouses. It was determined that greenhouse temperature values are much greater than the temperature values suggested for the one month growth period of pepper plant. Therefore, researchers indicated that under such adverse conditions pepper growth becomes slow down, flowering and fruit formation set is hindered and yield decreases occur (Salk et al., 2008) and ventilation is required since greenhouse temperature increases to values above 30^oC (Sevgican, 1999). It was observed when humidity values were controlled that PNG from among plastic greenhouses has the highest average humidity (75%), while GCG had the highest average humidity (71,74%) among glass greenhouse. It was observed with regard to average solar radiation according to Figure 2 that PCG has the highest value among plastic greenhouses (226,78 Wm^{-2}), while GCG (195,07 Wm^{-2}) has the highest value among glass greenhouses. Therefore, measurements in all greenhouses are higher than the recommended minimum solar radiation values for photosynthesis.

Highest solar radiation was measured on this measurement day as 322,9 Wm^{-2} at PCG at 12:00. Minimum solar radiation falling directly onto the leaf surface was observed as 80-110 Wm^{-2}, it has been indicated by researchers that this value should be 500 Wm^{-2} in order for photosynthesis to develop completely on all leaves (Tunçbilek, 2019). Researchers have indicated that the pepper plant partially likes light and that there may be increases in the number of leaves with decreasing light intensity. Therefore, flower bud formations decrease and fruit yield slows down. Moreover, it has also been put forth that fruit yield increases with increasing solar radiation (Anonymous, 2019b). Bio-agents were placed inside the greenhouse during this development stage. We are of the opinion that higher temperature and solar radiation values on November 15, 2017 for greenhouses with insect net are due to the use of nets.

The month of December which is another measurement date is also the period during which the first harvest took place (Figure 3). The temperature values suggested for the pepper plant during this period range between 21-27^oC. It was observed when the average temperature values for the 4 greenhouses included in the study during the aforementioned dates were examined that PCG has the highest average temperature value (31,40^oC) among plastic greenhouses and that GNG has the highest average temperature (34,17^oC) among glass greenhouses (Figure 3). It was determined that PCG has the highest average value with regard to relative humidity (%49,39) on 15.12.2017 among plastic greenhouses and that GCG (64,87%) has the highest average relative humidity value among glass greenhouses. The recommended humidity values did not occur in all four greenhouses. However, if the humidity is high and low, it is stated that pepper plant affects the yield and quality negatively (Aktas et al., 2003; Aktas et al., 2005).

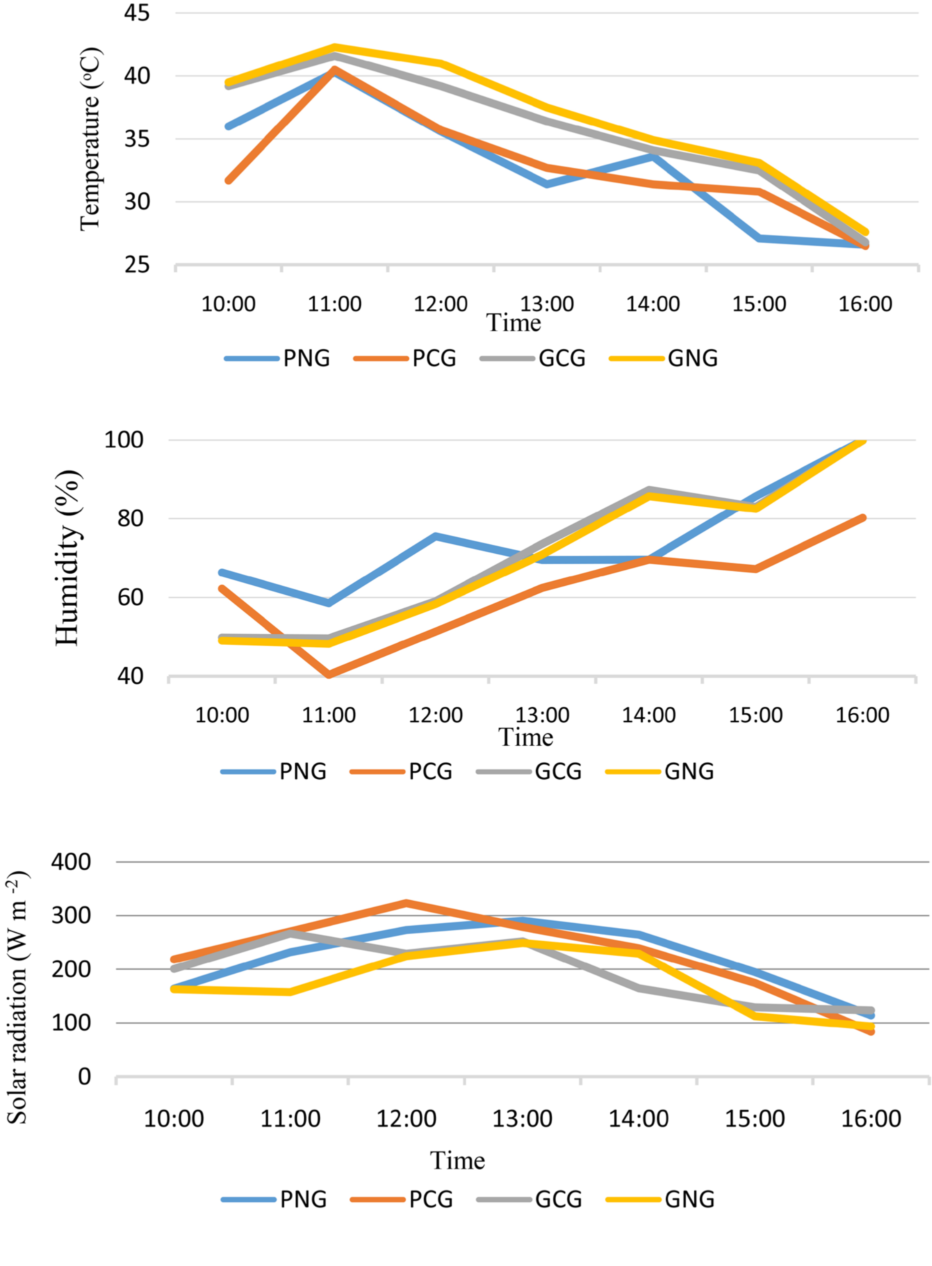

Figure 2. Temperature, humidity and solar radiation values (15.11.2017)

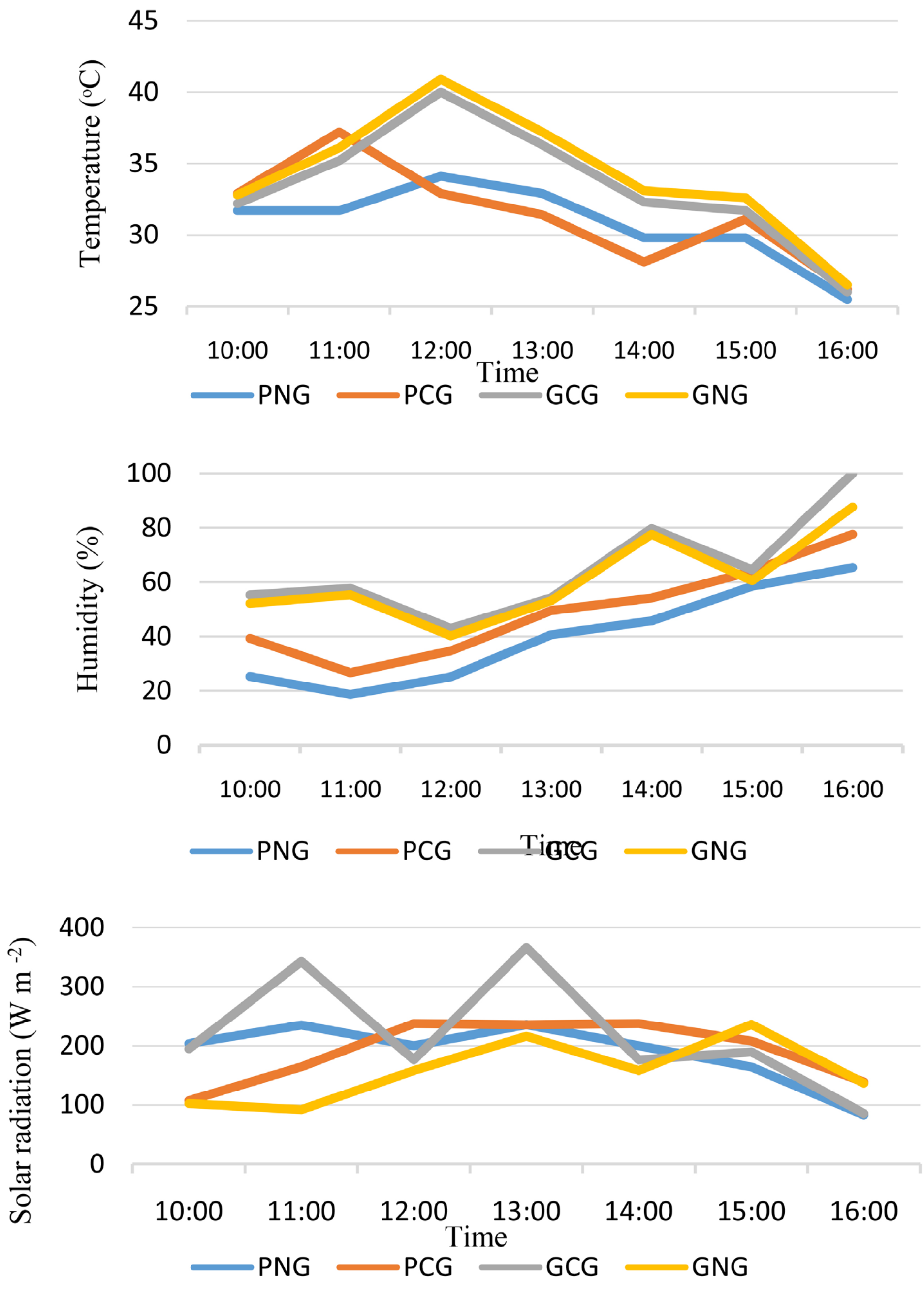

Figure 3. Temperature, humidity and solar radiaton values (15.12.2017)

With regard to average solar radiation values, it was observed that GCG (218,8 W m^{-2}) has higher values in comparison with GNG (157,02 Wm^{-2}) and that PNG (188,91 Wm^{-2}) and PCG (189,82 Wm^{-2}) have very close values. Highest solar radiation for GCG was measured as 366,6 Wm^{-2} at 13.00. Therefore, it can be indicated that lower solar radiation values for GNG and PNG may be due to the insect net cover material (Figure 3). In addition, the development of bio-agents was also taken into consideration starting from this period. The best temperature requirement for the development of bio-agents *Orius Leavigatus* has been indicated by the researchers as 20-30°C (Alauzet, 1994), as 20-30°C (Heung-Su, 2011) for *Amblyseius swirski* and as 30°C and above (Hoffmann and Frodsham., 1993) for *Phytoseiulus persimilis* whereas the humidity requirement has been indicated as 20-25°C (Goh et al., 2001) for *Aphidius Colemani* as %60-90 (Shipp, 2003). It has been determined under these conditions that the average temperature values are high for the development of *Amblyseius swirski* and *Orius Leavigatus* under these conditions in all greenhouses. It was observed that the desired temperature values are suitable for *Phytoseiulus persimilis* in all greenhouses. It was determined that the required average temperature values for the development of *Aphidius Colemani* cannot be attained in any greenhouse and that the required average relative humidity values can be met only in glass greenhouses.

The month of January is the development period for pepper plant and its bio-agents. The temperature requirement for pepper during this period is 21-26°C. According to the graphs in Figure 4, it was observed that the temperature required for the growth of pepper plant has been obtained in every greenhouse at which measurements have been made on January 16. When examined in Figure 4, it was determined that the highest average temperature values were measured in PNG. Therefore, we can say that this high temperature is due to the effect of insect net.

The required relative humidity values for pepper have been attained, the best average relative humidity values have been attained in plastic greenhouses PCG (%71,81) and the required relative humidity values have not been attained in glass greenhouses (Figure 4). With regard to the average solar radiation amounts, it was observed that the highest values have been obtained in PNG from among plastic greenhouses (111,47 Wm^{-2}), and in GCG (129,47 Wm^{-2}) from among glass greenhouses (Figure 4). Highest solar radiation for GCG was measured as 366,9 Wm^{-2} at 12.00. The average solar radiation values in January are lower than the other measurement dates. We can say that these values are due to insect net and low sunshine rate in January. However, the measured values were found to be higher than the minimum recommended solar radiation values for photosynthesis. The suggested average temperature values suggested for the bio-agents *Amblyseius swirski* and *Orius Leavigatus* have been attained in all greenhouses. The average temperature values suggested for *Phytoseiulus* *persimilis* could not be attained in any greenhouse. It was observed that the average temperature values suggested for *Aphidius Colemani* have been attained in PCG from among plastic greenhouses (23,04°C) and that these values have been attained in both glass greenhouses. It was determined that the suggested average relative humidity values for *Aphidius Colemani* have been attained in all greenhouses.

It has been indicated according to Table 2 that the required temperature value varies between 21-26°C since the month of February is indicated as the growth period for the pepper plant. It was observed upon examining Figure 5 that the measured average temperature values are below 15°C in all greenhouses. Since the lowest temperature requirement for the growth of pepper plant is below 15°C, the growth of pepper plant is hindered with adverse impacts on pollination (MEGEP, 2008). The average relative humidity suggested for the growth of the pepper plant could not be attained. The measured average relative humidity values were below the suggested values for plastic greenhouses PNG (%51,60) and PCG (%54,16), whereas data could not be acquired from glass greenhouses since the humidity sensors were out of order (Figure 5) Thus, humidity graphs could not be prepared for these greenhouses. According to solar radiation measurements, the average solar radiation value was highest for PCG (229 Wm^{-2}) from among plastic greenhouses, and for GCG (314 Wm^{-2}) from among glass greenhouses. In the greenhouse where both insect tulle was used, solar radiation values were lower than other greenhouses (Figure 5). It has been determined that the minimum recommended solar radiation values for photosynthesis are achieved in all greenhouses. It was observed when the average temperature values measured for bio-agents were examined that temperature values that are not suited for bio-agent development have been obtained. It was also observed that the best humidity measurement value for *Aphidius Colemani* development has been obtained in glass greenhouses and that the required humidity could not be attained in plastic greenhouses.

The month of April is the period during which lower leaf pruning is carried out for the pepper plant and the period during which the pepper plant starts its growth. The temperature value suggested for the pepper plant during this period is 21-27 °C. As can be seen in Figure 6, it was observed according to April 7 measurement values that; the highest average temperature value has been obtained in PNG from among plastic greenhouses (34,29°C), and in GNG from among glass greenhouses (31,47°C). It was determined that the temperature values reached the limit values of pepper plant in insect net applied greenhouses. Researchers have reported that air temperatures above 35-36 °C may adversely affect the development of pepper plant. It is stated that these conditions can lead to seed-free fruit formation and fruit deformations (Salk et al., 2008). Whereas it was observed that even though the highest average humidity value was obtained in PCG from among plastic greenhouses (%15,30) it is still much below the suggested humidity value and that the lowest value from among glass greenhouses has been obtained in GNG (% 68,83) and that there is not much difference between the value obtained for GCG (%70,54).

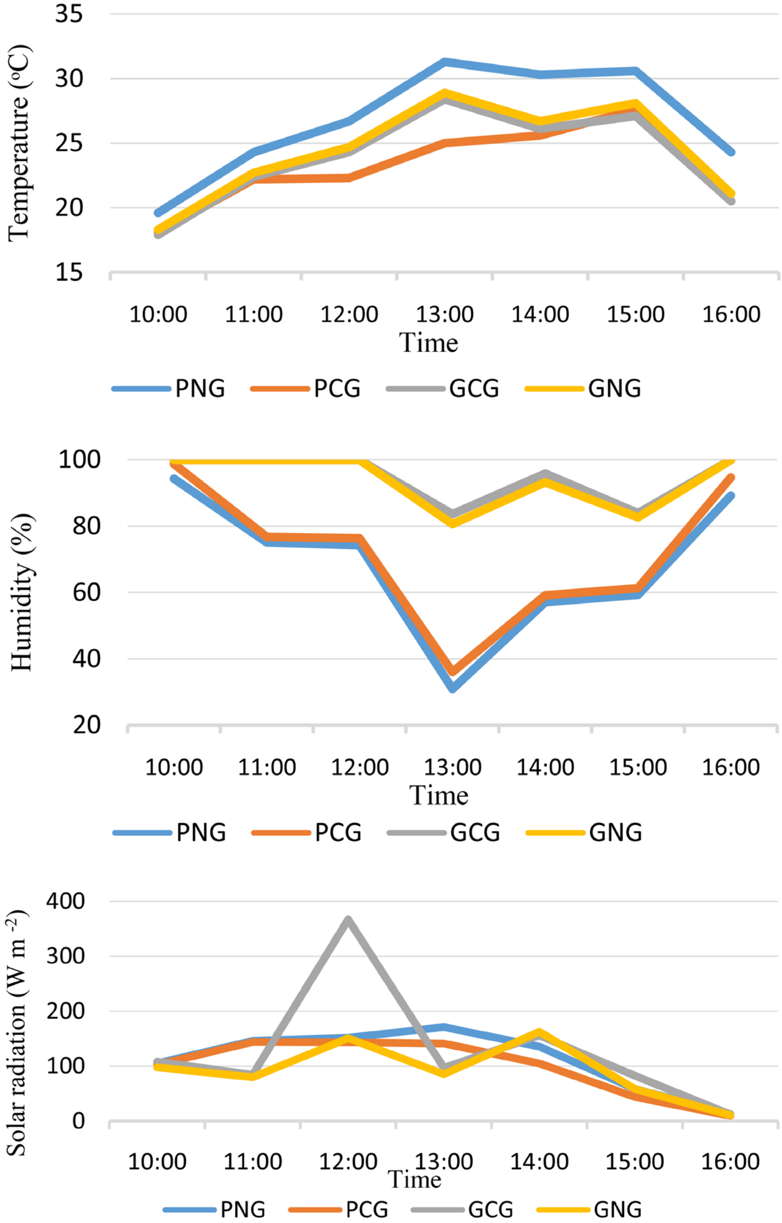

Figure 4. Temperature, humidity and solar radiation values (16.01.2018)

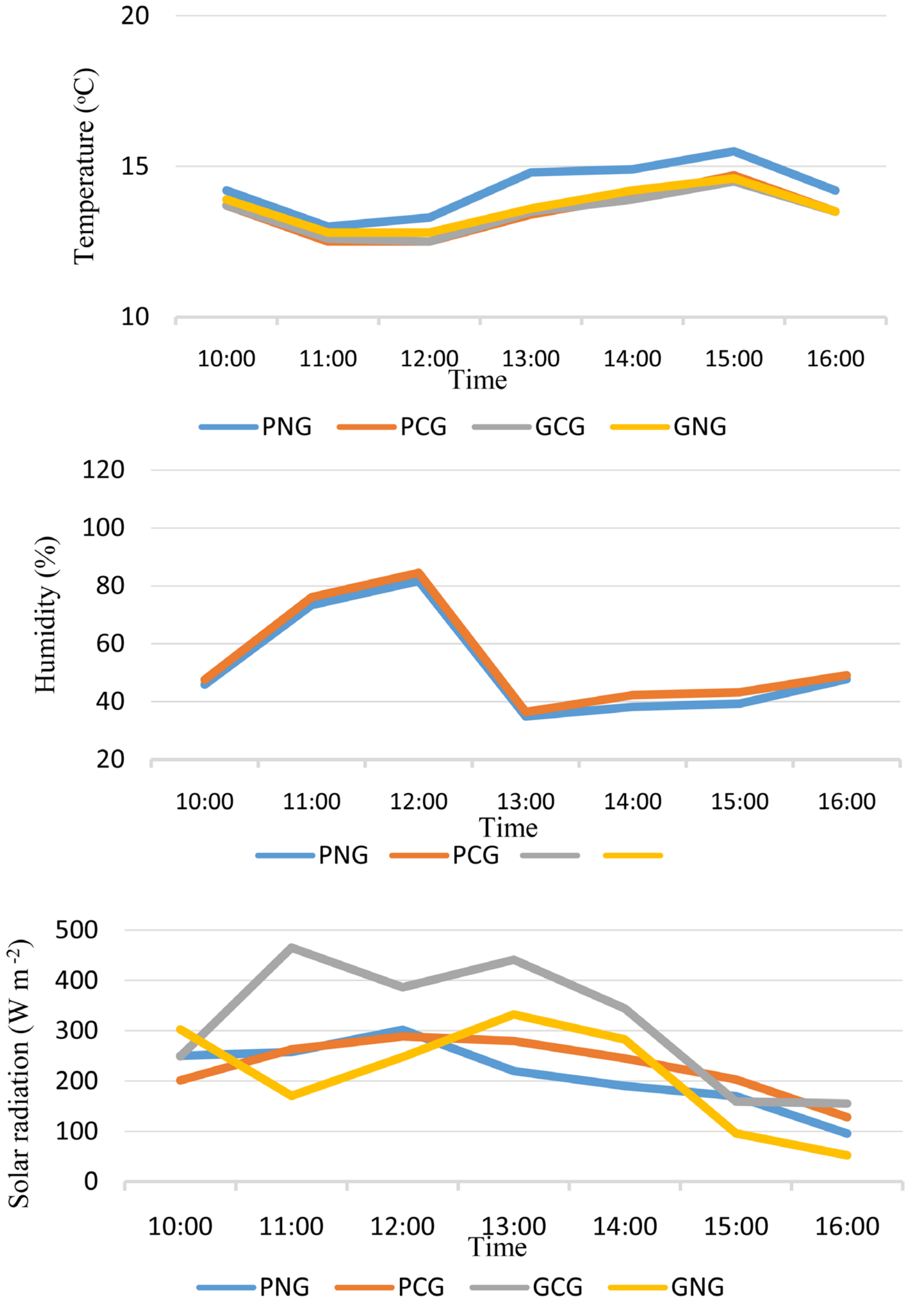

Figure 5. Temperature, humidity and solar radiation values (16.02.2018)

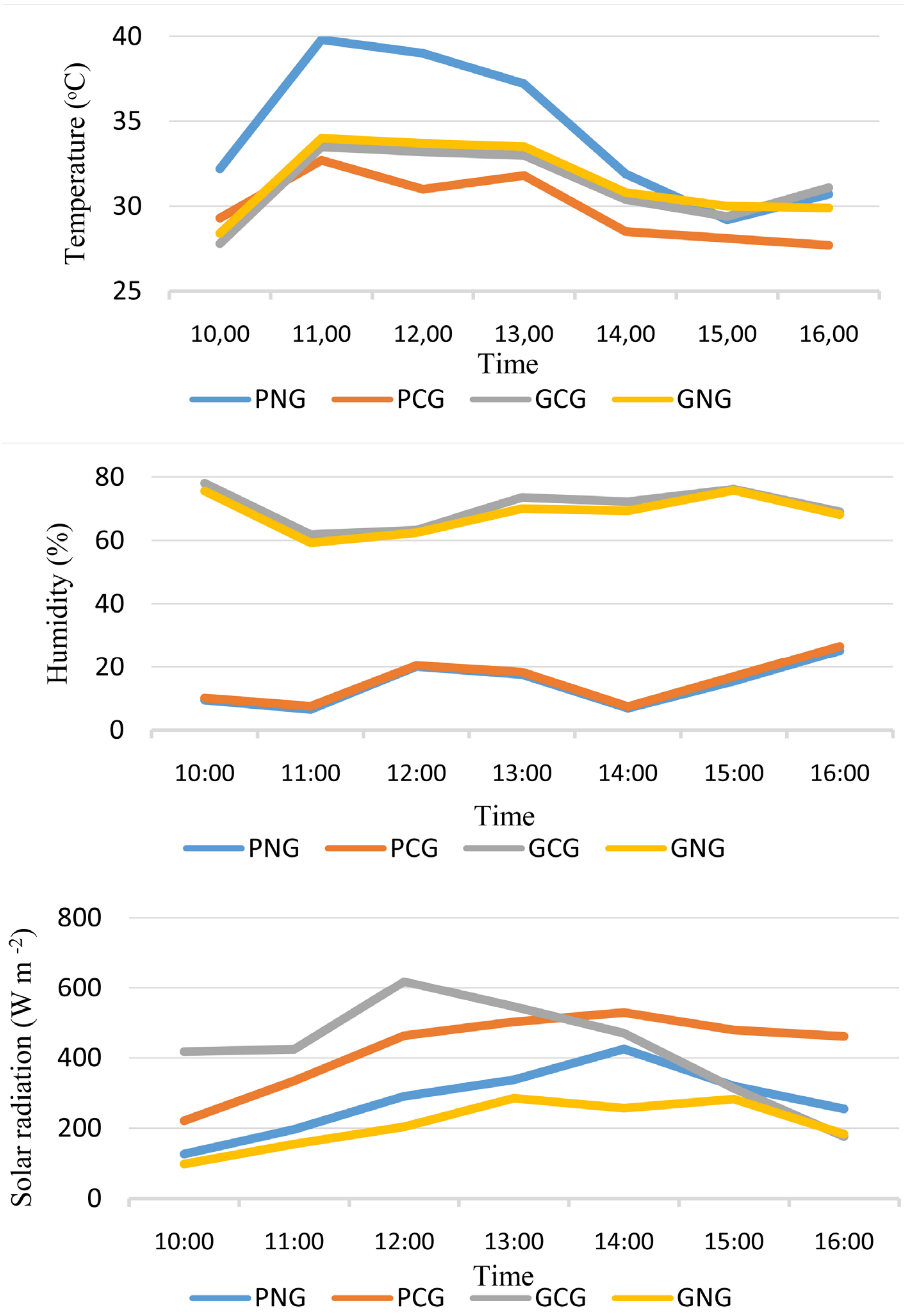

Figure 6. Temperature, humidity and solar radiation values (07.04.2018)

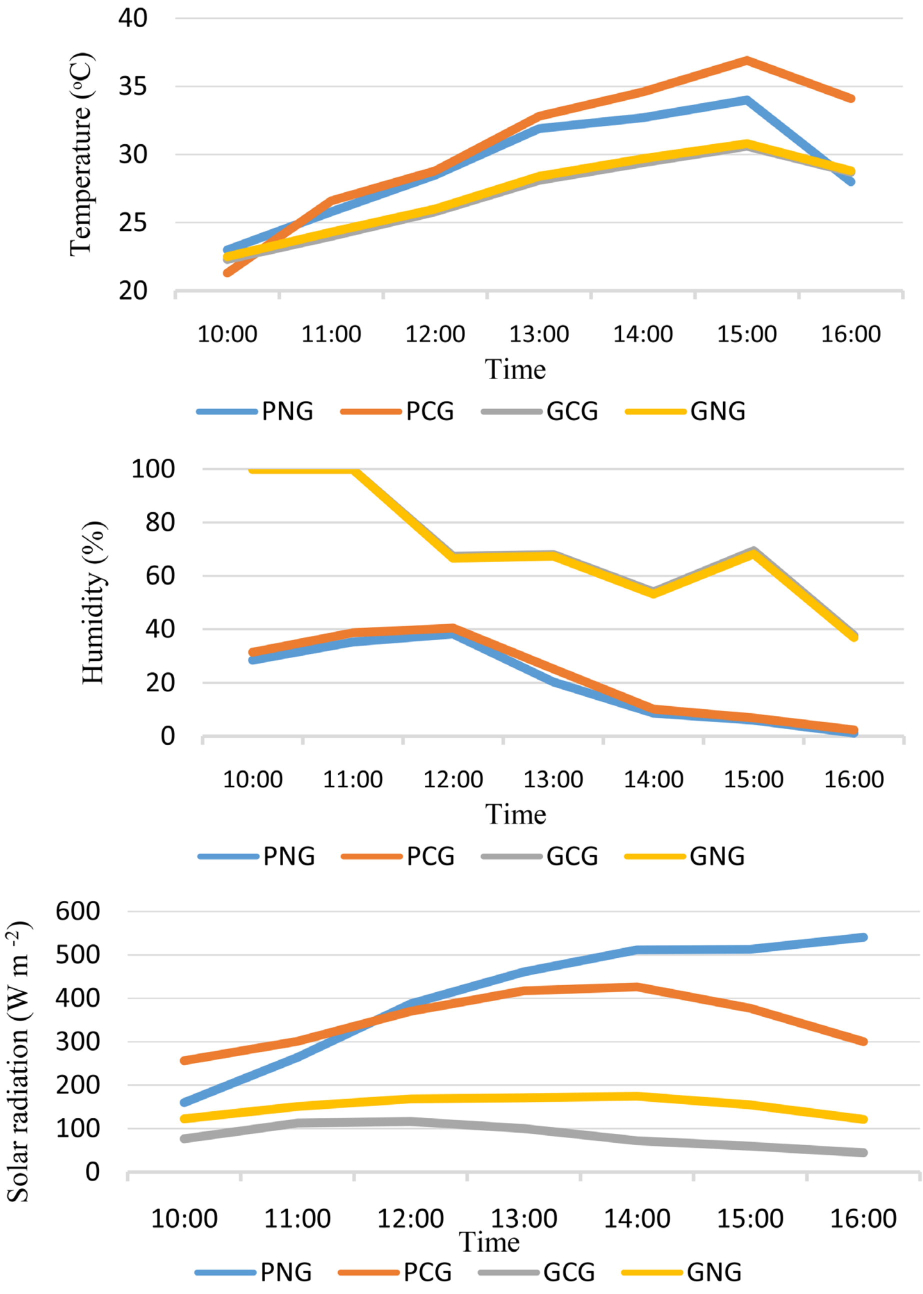

Figure 7. Temperature, humidity and solar radiation values (11.05.2018)

It was determined that the highest average solar radiation was obtained in PCG from among greenhouses (427 Wm^{-2}), and in GCG (423 Wm^{-2}) from among glass greenhouses. These average solar radiation values indicate that these values are almost obtained so that photosynthesis can occur in all leaves. Highest solar radiation for GCG was measured as 617.6 Wm^{-2} at 12.00 (Figure 6). This is the development period for bio-agents. It was observed when the average temperature values were taken into consideration during this period that the lowest value has been obtained in PCG from among plastic greenhouses (29,87°C) and in GCG (31,20°C) from among glass greenhouses.

Therefore, it can be stated that the suggested temperature values for the development of the bio-agents *Amblyseius swirski* and *Orius Leavigatus* have been attained only in PCG (29,87°C). The suggested temperature values for *Phytoseiulus persimilis* have been attained in all greenhouses. Thus, it can be stated that the high average temperature values in plastic greenhouses are due to the insect net. The suggested average temperature values for *Aphidius colemani* from among the bio-agents could not be attained in any greenhouse. It was observed when the average relative humidity values were examined that the measured values are not sufficient in plastic greenhouses and that the lowest average relative humidity value in glass greenhouses was obtained in GNG (%68,63) which meets the suggested humidity value.

The month of May is the final harvest period for the pepper plant and also the period during which the development of bio-agents continue. The temperature value suggested for the pepper plant is indicated as 21-27°C. It has been observed according to Figure 7 that the lowest value has been obtained in PTS from among plastic greenhouses (29,13°C), and in GCG from among glass greenhouses (26,99°C) and that the temperature values in all greenhouses were above the suggested values. According to relative humidity value measurements; it was observed that the highest values were obtained in PCG from among plastic greenhouses (%22,14) and in CKS from among glass greenhouses (%70,96). It can be stated according to these values that plastic greenhouses are much below the suggested humidity values and that the converse is true for glass greenhouses.

Whereas the highest average radiation energy values were obtained in PNG from among plastic greenhouses (405 Wm^{-2}), and in GNG (151 Wm^{-2}) from among glass greenhouses. The lowest average temperature values for bio-agents *Amblyseius swirski* and *Orius Leavigatus* according to May 11 measurements were obtained in PNG from among plastic greenhouses (29,13°C) and in GCG (26,99°C) from among the glass greenhouses and that these values are sufficient for the development of these bio-agents. Whereas the suggested temperature values could not be attained in any of the 4 greenhouses for *Aphidius colemani*. According to the average humidity values, it was observed that the required humidity values are met in glass greenhouses and that the values for plastic greenhouses are much below the suggested humidity values.

Statistical Results

T test was applied for interpreting the differences between the solar radiation and the temperature values obtained in the study. Statistical results for solar radiation and temperature values are presented in Tables 3 and 4.

Table 3. Descriptive statistics of solar radiation and T test results

Date	Greenhouse Type	Number of Samples	Average	Standard Deviation	Standard Error
15.11.2017	PNG	1020	97.82 B	3.42	109.29
	PCG	1020	102.45A	3.68	117.43
15.11.2017	GCG	1020	91.39 A	3.43	109.41
	GNG	1020	86.88 B	3.27	104.5
15.12.2017	PNG	1020	84.30 A	3.18	101.48
	PCG	1020	75.42 B	2.8	89.51
15.12.2017	GCG	1020	108.36 A	4.41	140.94
	GNG	1020	71.58 B	2.98	95.07
16.1.2017	PNG	1020	55.90 A	2.29	73.12
	PCG	1020	50.36 B	1.99	63.6
16.1.2017	GCG	1020	48.95 A	2.08	66.27
	GNG	1020	49.01 A	2.05	65.6
16.2.2017	PNG	1020	99.55 B	3.38	107.87
	PCG	1020	103.82 A	3.57	114.13
16.2.2017	GCG	995	137.86 A	5.11	161.19
	GNG	1020	86.96 B	3.68	117.55
7.4.2017	PNG	1020	146.73 B	4.44	141.85
	PCG	1020	204.10 A	6.33	202.16
7.4.2017	GCG	1020	186.86 A	6.60	210.90
	GNG	1020	110.26 B	3.38	108.10
11.5.2017	PNG	1020	225.15 A	6.54	208.76
	PCG	1020	183.89 B	4.89	156.16
11.5.2017	GCG	1020	42.46 B	1.24	39.69
	GNG	1020	80.32 A	2.13	68.16

Table 4. Descriptive statistics of temperature and T test results

Date	Greenhouse Type	Number of Samples	Average	Standard Deviation	Standard Error
15.11.2017	PNG	24	21.46 A	1.77	8.70
	PCG	24	21.39 A	1.71	8.37
15.11.2017	GCG	24	22.33 B	2.00	9.79
	GNG	24	22.86 A	2.04	10.00
15.12.2017	PNG	24	17.83 A	1.82	8.93
	PCG	24	17.70 A	1.98	9.68
15.12.2017	GCG	24	18.14 B	2.18	10.7
	GNG	24	18.63 A	2.23	10.9
16.1.2018	PNG	24	16.09 A	1.56	7.63
	PCG	24	13.83 B	1.35	6.62
16.1.2018	GCG	24	14.04 B	1.43	7.01
	GNG	24	14.40 A	1.46	7.14
16.2.2018	PNG	24	13.121 A	0.241	1.181
	PCG	24	12.592 B	0.204	0.998
16.2.2018	GCG	24	12.467 B	0.216	1.058
	GNG	24	12.621 A	0.22	1.076
7.4.2018	PNG	24	21.64 A	2.05	10.03
	PCG	24	19.74 B	1.77	8.65
7.4.2018	GCG	24	19.95 B	1.89	9.24
	GNG	24	20.44 A	1.87	9.19
11.5.2018	PNG	24	21.81 B	1.28	6.27
	PCG	24	22.85 A	1.48	7.23
11.5.2018	GCG	24	21.40 B	1.02	4.99
	GNG	24	21.63 A	1.02	5.00

It was observed when the solar radiation measurement values on November 15, 2017 and February 16 and April 7, 2018 were examined that PCG has a higher value than PNG and that GCG has a higher value than GNG with the differences observed to be statistically significant. It was observed according to the measurements on December 15, 2017 that PNG has a higher value than PCG and that GCG has a higher value than GNG. The differences were observed to be statistically significant. The researchers stated that the nets used in agricultural production reduce the light intensity (Song et al., 2012; Zhao et al., 2012). This shows that our values are similar with the findings of the researches. PNG was observed to be higher at a statistically significant level in comparison with PCG according to the measurements on January 16, 2018. It was observed according to the measurements on May 11, 2018 that PNG has a higher value than PCG and that GNG has a higher value than GCG with the differences observed to be statistically significant.

According to measurements on November 15 and December 15, 2017; it was observed that GNG has a higher value than GCG with a statistically significant difference. It was observed according to the measurements on January 16, February 16 and April 7, 2018 that PNG has a higher value than PCG and that GNG has a higher value than GCG with the differences observed to be statistically significant. It was determined when the temperature values on May 11, 2018 were observed that PCG and GNG have values higher at a statistically significant level in comparison with PNG and GCG.

CONCLUSIONS

It was determined when the temperature values obtained as a result of the study were examined that the suggested temperature values are high for the dates of November 15, December 15, April 7 and May 11 and that these values are higher for greenhouses in which insect net has been used. For example, the average temperature values on April 7, 2018 during 10.00-16.00 were observed as 34,29^{o}C for PNG and as 29,87^{o}C for PCG which were also statistically significant. The temperature value for GNG (31,47^{o}C) on the same date was observed to be higher at a statistically significant level in comparison with GCG (31,20^{o}C). It can be indicated that insect net use has significant impacts on temperature values as well as solar radiation values. It was observed that the solar radiation values were low for greenhouses with insect net (November 15, December 15, February 16 and April 7). For example, the average radiation energy values on April 7 were determined as 278 Wm^{-2} in PNG from among plastic greenhouses and as 427 $W\ m^{-2}$ in PCG whereas the values were determined as 423 Wm^{-2} for GCG from among glass greenhouses and as 209 Wm^{-2} for GNG. Thus, it was determined that low solar radiation values are due to the use of insect net and that the solar radiation values entering the greenhouse decrease as a result. It was determined when the humidity values obtained as a result of the study were examined that the relative humidity values were lower in greenhouses with insect net. According to the average temperature value results for biological control agents excluding the month of February; it can be indicated that development slows down for *Amblyseius swirski* and *Orius Leavigatus* which are bio-agents that are resistant to high temperature, whereas it is a proper environment for the development of *Phytoseiulus persimilis* (30^{o}C and above) and that the eggs emerge in a shorter amount of time. It can be stated that the best average temperature value required for the development of *Aphidius colemani* is observed only in the month of January and that the development of this agent slows down during the other months with lower parasitical levels since it is a parasitoid insect. Hence, high temperature values and low solar radiation values are not desired for greenhouses with insect net. However, the use of insect net can make a positive impact for various bio-agents since it leads to an increase in greenhouse temperature. Producers who use insect net should carry out their production activities by taking into consideration these negative impacts of temperature and solar radiation.

ACKNOWLEDGEMENT

The authors would like to thank SDU-BAP (Suleyman Demirel University, Scientific Research Projects) for its financial support during their study (Project no. 5042-YL1-17).

REFERENCES

Akça, M. (2013). t-Test hypothesis tests. https://www.printfriendly.com/p/g/3nzrXL (Date: 24.09.2019).

Aktas, H., Karni, L., Aloni, B., Bar-Tal, A. (2003). Physiological and biochemical mechanisms leading to blossom end rot in greenhouse-grown peppers, irrigated with saline solution. Acta Horticulturae, 609: 81–88.

Aktas, H., Karni, L., Chang, D. C.,Turhan, E., Bar-Tal,A., Aloni, B. (2005).The suppression of salinity-associated oxygen radicals production, in pepper (*Capsicum annuum* L.) fruit, by manganese, zinc and calcium in relation to its sensitivity to blossom-end rot. Physiologia Plantarum, 123: 67–74.

Alauzet, C., Dargagnon, D., Malausa, J.C. (1994). Bionomics of a polyphagous predator: Orius laevigatus (Het.:Anthocoridae) Entomophaga, 33-40.

Anonymous, (2008). Biber yetiştiriciliği. http://hbogm.meb.gov.tr/modulerprogramlar/kursprogramlari/ bahcecilik/moduller/biber_yetistiriciligi.pdf (Date: 24.09.2019) (In Turkish).

Anonymous, (2019a).Ulker Ziraat, Anti-insect net http://ulkerziraat.com/index.php (Date: 24.09.2019).

Anonymous, (2019b). Serada Biber Yetiştiriciliği-Örtüaltı Biber Yetiştiriciliği. https://www.serada.org/serada-biber-yetistiriciligi.html (Date: 22.09.2019) (In Turkish).

Goh, H.G., Kim, J.H., Han, M.V. (2001). Serada Yaprak Bitinin Kontrolü İçin Aphidius colemani Viereck Uygulaması. Asya-Pasifik Entomoloji Dergisi 4(2): 171-174.

Güllüler, F. (2007). Adana İli ve İlçelerindeki Seraların Yapısal Özelliklerinin İncelenmesi ve T.S.E Standartlarına Uygunluğunun Araştırılması. (Yüksek Lisans Tezi, Çukurova Üniversitesi, Fen Bilimleri Enstitüsü Tarımsal Yapılar ve Sulama Anabilim Dalı Adana). (In Turkish).

Heung-Su, L. (2011). Farklı Sıcaklıklarda Amblyseius swirski (Acari: Phytoseiidae)'nın yaşam tabloları ve gelişimi. Deneysel ve Uygulamalı Akaroloji, 53(1): 17-27.

Hoffmann, M.P., Frodsham, A.C. (1993). Natural Enemies of Vegetable Insect Pests. Cooperative Extension, Cornell University, Ithaca, NY. 63.

Mahmood, A., Hu, Y., Tanny, J., Asantea, E.A. (2018). Effects of shading and insect-proof screens on crop microclimate and production: A review of recent advances, Scientia Horticulturae 241: 241–251.

MEGEP, (2008) T.C. Millî Eğitim Bakanlığı, Bahçecilik Biber Yetiştiriciliği, 47s. Ankara. (In Turkish)

Sevgican, A. (1999). Örtüaltı Sebzeciliği I (Topraklı Tarım). Ege Üniversitesi Ziraat Fakültesi Yayınları No:528, Ege Üniversitesi Basımevi, İZMİR. (In Turkish).

Song, R., Kelman, D., Johns, K.L., Wright, A.D. (2012). Correlation between leaf age, shade levels, and characteristic beneficial natural constituents of tea (Camellia sinensis) grown in Hawaii. Food Chem. 133:707–714.

Shipp, J.L., ZHang, Y., Hunt, D.W.A., Ferguson, G. (2003). Influence of Humidity and Greenhouse Microclimate on the Efficacy of Beauveria bassiana (Balsamo) for Control of Greenhouse Arthropod Pests. Environmental Entomology. 32(5): 1154-1163.

Salk, A., Arin, L., Deveci, M., Polat, S. (2008). Specialty Vegetables. Namık Kemal University, Faculty of Agriculture, Horticulture Science, Tekirdağ. pp 488. (In Turkish).

Ocak, A. (2019). Seralarda Kullanılan İnsect Tülün İç Ortam Koşullarına Etkisinin Belirlenmesi: Biber Bitkisi Örneği, ISUBU, Lisansüstü Eğitim Enstitüsü, Yüksek lisans tezi, pp40, Isparta. (In Turkish).

TUİK, (2019). Türkiye İstatistik Kurumu. http://www.tuik.gov.tr/PreTablo.do?alt_id=1001 (Date: 24.09. 2019).

Tunçbilek, F. (2019). Sera Yetiştiriciliğinde Farklı Renklerdeki Örtü Malzemelerinin Gelişim Üzerine Etkileri: Marul Örneği (YL Tezi, Isparta Uygulamalı Bilimler Üniversitesi, Lisansüstü Eğitim Enstitüsü). Uygun, N., Ulusoy, M.R., Satar, S. (2010). Biyolojik Mücadele. Türkiye Biyolojik Mücadele Dergisi, 1(1): 1-14. (In Turkish).

Zhao, D., Hao, Z., Tao, J. (2012). Effects of shade on plant growth and flower quality in the herbaceous peony (Paeonia lactiflora Pall.). Plant Physiol. Bioch. 61: 187–196.

Corresponding author: Prof. Dr. Atılgan Atılgan
E-mail: atilganatilgan01@gmail.com
Orcid : 0000 0003 2391 0317
Aytekin Ocak, MSc.
E-mail: aocak@koppert.com.tr

Isparta University of Applied Sciences
Faculty of Agricultural Sciences and Technologies
Department of Agricultural Structure and Irrigation
32160-Çünür-Isparta-TURKEY

Received: 06.09.2019
Accepted: 06.10.2019