INFRASTRUKTURA I EKOLOGIA TERENÓW WIEJSKICH
INFRASTRUCTURE AND ECOLOGY OF RURAL AREAS

No III/1/2019, POLISH ACADEMY OF SCIENCES, Cracow Branch, pp. 235-252
Commission of Technical Rural Infrastructure

DOI: https://doi.org/10.14597/INFRAECO.2019.3.1.017

INVESTIGATION OF HEATING AND COOLING DEGREE-HOUR VALUES IN GREENHOUSES WITH DIFFERENT COLOR COVER MATERIALS: THE CASE OF LETTUCE PLANT

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Abstract

In this study, it is aimed to determine the effect of greenhouse cover material of different color on the number of heating (HDHN) and cooling degree hours (CDHN) and heating (HDH) and cooling degree hours (CDH) of the lettuce plant. For this purpose, the study was carried out in the CtrlG (Control transparent PE greenhouse), RedG (Red PE greenhouse) and BlueG (Blue PE greenhouse). The study was completed in 2018 at ISUBU research and application farm. The temperature values measured in the three greenhouses with the same dimensions were the material of the study. HDH, CDH, HDHNs, and CDHNs were calculated by examining the measured temperature values and suggested temperature values for the lettuce plant. By using these values, it was tried to determine suitable cover material during the growing period of the lettuce plant. It has been concluded that the use of colored covering material is more suitable in terms of energy needs in almost all growing periods of lettuce plants. By comparing the values calculated for RedG and BlueG based on CtrlG, the coefficients of variation were calculated to determine which data series or series were more similar to each other. According to the coefficients of variation, the average values of HDH, CDH, HDHNs and CDHNs of the control greenhouse and other colored covered greenhouses ranged between 1,365 and 14,102%. Based on the CtrlG, BlueG was more homogeneous (1,365-8,364%), whereas RedG was less homogeneous (3,798-14,102%). It can be said that the use of colored covering material in greenhouses for lettuce plants will be more advantageous in terms of energy requirement.

Keywords: Cover Material, Degree-hours, Greenhouse, Heating, Cooling,

INTRODUCTION

One of the benefits of greenhouse farming is the option to control fundamental factors related to plant production with impacts on environment control such as light, humidity, amount of carbon dioxide and ventilation. Temperature is among the most important factors with an impact on plant growth in greenhouse conditions. Plant species produced in greenhouses require different optimum growth temperatures during their growth stages. Plant yield and quality parameters are directly influenced by increases or decreases in these temperature values (Boyacı et al. 2017). Light quality and the position of light sources with respect to the plants have a significant impact on product yield. Radiation energy emitted from the light source which strikes a surface is proportional with the inverse of the square of the distance between them (Bickford and Dunn 1972). Thus, decreasing this distance will have a major impact on light intensity. Various studies have been carried out for determining which colors and light types are suited for plant growth (Massa et al. 2010).

It has been put forth in various studies that the blue and red light spectrum is the best for photosynthesis. It has been put forth in various studies that the blue and red light spectrum is the best for photosynthesis (Anonymous 2018, Tunçbilek 2019).

Chlorophyll reflects the majority of the green wavelengths and does not use them in photosynthesis. Therefore, plants absorb purple-blue and red light waves more and use them in photosynthesis (Büyük 2018, Tunçbilek 2019).

There are various methods for calculating monthly or yearly energy consumption; however, degree-hour or degree-day methods are the simplest. The degree-day method may provide a simple but quite accurate estimation for the annual energy loads if the internal temperature is constant. It has been indicated that the Degree-hour and degree-day methods are used frequently for estimating energy consumption in heating systems during winter time and cooling systems in summer months. (Satman and Yalçınkaya 1999).

Similar to the degree-day method, the energy required for heating or cooling a building is proportional to the ambient temperature and an equilibrium temperature in the Degree-hour method. Researchers have reported that the Degree-hour method provides more sensitive results in comparison with the degree-day method (Bulut et al. 2007). The main purpose of the present study was to determine the impact of different colored cover materials used in greenhouses on heating and cooling HDH, CDH, HDHN and CDHN values for the lettuce plant.

MATERIAL AND METHOD

The study was carried out in the greenhouses with three different colors (Control greenhouse white PE (CtrlG), Red PE (RedG) and Blue PE (BlueG)) covering materials in the research and application center of the University of Applied Sciences in Isparta. The dimensions of the three greenhouses are the same (2,7x3x6) m. During the research, the 65-day (April-May-June 2018) hourly temperature values measured in the greenhouse were used as material. Using these values, HDH, CDH, HDHN, and CDHN were calculated for each greenhouse. In order to calculate these values, the basic temperature (Tb, ºC) values recommended for lettuce cultivation, in general, are used in Table 1 (Aktaş 2019, Tuçbilek 2019).

Table 1. Recommended Temperature Values in Lettuce Cultivation

Growth period	April				May				June			
	Growing time (week)											
	1	2	3	4	5	6	7	8	9	10	11	12
Seed and Germination Period			4-29ºC									
Seedling Period				10-18ºC								
Growing Period						7-21ºC						
Jointing and Harvest Period										15-27ºC		

Lettuce (*Lactuca sativa var. longifolia*) was used as plant material. The seeds sowed in small pots in April. The seedling was planted in 10 m^2 covered plastic greenhouse covered different colors of plastic material after 3 weeks. The plant was irrigated according to soil humidity annealing and feeding to modified Hogland nutrient solution.

Heating and Cooling Degree-Hour Method: The degree of heating and cooling-hour is used to express the severity of a given base temperature at a given time. The number of hours of heating degree is equal to the total number of hours of heating during the day in the heating season, and the number of days of cooling degree is equal to the total number of hours of the day of cooling. Heating and Cooling Degrees-Hours (HDH and CDH), Heating and Cooling Degrees-Hour numbers (HDHN and CDHN) are calculated by the following equations.

$$HDH = (Tb - T_{avr})^{+}$$
$$HDHN = \sum_{i=1}^{n} HDH \tag{1}$$

$$CDH = (T_{avr} - T_b)^{+}$$
$$CDHN = \sum_{i=1}^{n} CDH \tag{2}$$

Here; Tb recommended basic temperature values, T_{avr}, average daily outdoor temperature and n the number of days in the recommended breeding period (Day and Karayiannis 1998, Buyukalaca et al. 2001, Aydın et al. 2015, Bayram and Yeşilata 2019). In the above equations, the calculations were made considering positive values. HDH, CDH, HDHN and CDHN values calculated for CtrlG and HDH, CDH, HDHN and CDHN values calculated for other colored greenhouses were compared and the paired sample t test was performed. Paired Sample t Test**:** In statistics, it is important to determine and interpret the most appropriate test for the data series obtained from the research. This test is used to determine the difference between the means of two or more data series performed at the same time and the same research topic. The paired sample t test is calculated with the following equation.

$$D = D_i - D_j \tag{3}$$

$$\bar{D} = \frac{\sum_{i=1}^{n} D}{n} \tag{4}$$

$$S = \frac{\sqrt{\sum_{i=1}^{n} D^2 - \frac{\left(\sum_{i=1}^{n} D\right)^2}{n}}}{n-1} \tag{5}$$

$$S_{\bar{D}} = \frac{S}{\sqrt{n}} \tag{6}$$

$$t_{calculated} = \frac{\bar{D}}{S_{\bar{D}}} \tag{7}$$

Here; $t_{Calculated}$ is the test statistic value, the mean value of the data series i (Di) and the value of the other j data series (Dj) and Differences between i and j data series (D), $\bar{D}$ is average of differences, S is the standard deviation of the average of the differences, $S_{\bar{D}}$ is standard error of average of the differences and n is the number of observations. The t distribution at a given level of significance (α) and degree of freedom (v=n-1) is compared with the table value (t_{Table}). In the case of $t_{Calculated} > t_{Table}$, it is decided that there is no difference between the means of the data series, that is, they are not different from each other (Demirutku et al. 2005, Shammugasundram 2012, Aksaraylı 2018). The coefficient of variation was determined in order to determine the most homogeneous greenhouse covering material among the same time and the same research greenhouses.

Coefficient of variation (CV): It is a measure which is used to determine the similarities (homogeneities) of data series or series by comparing the distributions of two or more data series.

$$CV = \frac{s}{\bar{x}}.100 \tag{8}$$

Here; CV is the coefficient of variation (%), Standard deviation of data series (s) and ($\bar{x}$) average (Helsen and Hirsch 1993, Keskici and Kocabaş 1998, Özdamar 2018, Şen 2018).

Regression analysis was carried out to determine the relationships between HDH, CDH, HDHN, and CDHN values and recommended temperature values (Tb) calculated for each growing period in three greenhouses with different colored cover materials. The statistical suitability of the developed equations was examined by correlation analysis (r), f test and probability (p) analysis at 5% significance level. Regression Analysis: It is a technique used to model the relationship between two or more variables in statistics. The objective is to estimate the value of the dependent variable for known values of the independent variables by estimating the parameters in the model established between the dependent variable and the independent variable. In general, the regression equation is expressed as follows.

$$Y = \mathrm{a} + \mathrm{b}.\mathrm{X} + \varepsilon \tag{9}$$

$$a = \bar{y} - b\bar{x} \tag{10}$$

$$b = \frac{\Sigma(x_i - \bar{x})(y_i - \bar{y})}{\Sigma(x_i - \bar{x})^2} \tag{11}$$

Here; Y is the dependent variable, X is the independent variable, whereas a and b are equation regression coefficients and indicates the error term (Draper and Smith 1981, Helsen and Hirsch 1993, Jaiswal et al. 2015, Özdamar 2018). Regression analysis is carried out using the correlation coefficient (r), F test and probability value (p).

Correlation Analysis (r): The source of the relationships between the variables in research may be different. One of the variables considered may be one of the factors affecting the other. In this case, whether there is a relationship between the two variables is a preliminary measure of information indicating the strength, shape, and direction of the relationship, if any. (Beard 1962, Helsen and Hirsch 1993, Shammugasundram 2012). Correlation coefficient (r);

$$r = \frac{\frac{\sum_{i=1}^{n}(x_i-\bar{x})(y_i-\bar{y})}{(n-1)}}{\sqrt{\frac{\sum_{i=1}^{n}(x_i-\bar{x})}{(n-1)}}.\sqrt{\frac{\sum_{i=1}^{n}(y_i-\bar{y})}{(n-1)}}} \quad (12)$$

Here; x_i is independent variable, y_i is dependent variable $\bar{x}$ is the average of independent series, $\bar{y}$ is the average of dependent series and n is the number of observations.

F Test: A method for testing the equality of two or more averages using variances. It is used to analyze purely random research models. The F test is calculated by the following equations.

$$S_i^2 = \frac{\sum_{i=1}^{n}(x_i-\bar{x_i})^2}{n_i-1} \quad (13)$$

$$S_j^2 = \frac{\sum_{j=1}^{n-k}(x_j-\bar{x_j})^2}{n_j-1} \quad (14)$$

$$F_{calculated} = \frac{S_i^2}{S_j^2} \quad (15)$$

Here; S_i^2 and S_j^2 are Standard deviations of data series *i and j*, x_i and x_j are observation values of i and j data series, $\bar{x_i}$ ve $\bar{x_j}$ are average *of i and j* data series, n_i and n_j are observation numbers of i and j data series. At a given level of significance (α) and degrees of freedom ($v_i = n_i$-1 and $v_j = n_i$ j-1), the F distribution is compared with the table value (F_{Table}). It is decided that there is a regression analysis in case of $F_{Calculated} > F_{Table}$ (Keskici and Kocabaş 1998, Demirutku et al. 2005, Shammugasundram 2012, Aksaraylı 2018, Özdamar 2018). Probability value (p). It is a value used for the purpose of determining the existence of statistical significance in researches, if any, and the difference that exists in this significance. In general, the probability value (p) is taken as 5% and requested to be less than 5% (0,05) (Dawson and Trapp 2004, Kul 2014).

RESULTS AND DISCUSSION

The temperature values obtained in the study were examined together with the temperature values suggested for the lettuce plant after which HDH, CDH, HDHN, and CDHN values were determined and plotted for each growth stage. The results for the first growth stage of the lettuce plant which is germination and seed stage are presented in Figure 1. It was concluded that the values are high due to the high heating and cooling values in CtrlG, that heat loss, especially during the night, is less in colored greenhouses compared to the control greenhouse as well as the shading effect during the daytime hours. Therefore, it can be stated that the use of colored cover materials will be advantageous for lettuce growth, especially in this growth stage. Whereas Aydıncıoğlu (2004), put forth that greenhouse internal temperature and humidity should be kept at certain intervals in order to provide the required internal environment conditions for the greenhouse. For this purpose, Aydıncıoğlu indicated that greenhouses should be ventilated, shaded and cooled during the summer season. Çolak (2002), has stated that temperature should be controlled in the greenhouse and that the heating required is among the most frequently studied topics since it requires high amounts of energy. Researchers have stated that opinions can be put forth on the energy requirement of any structure using the heating and cooling degree-day values. Çolak (2002), stated that heating costs may sometimes be as high as 65 % of all production costs. In short, it can be stated that using colored cover material during this growth stage will be beneficial with regard to heating or cooling energy requirements.

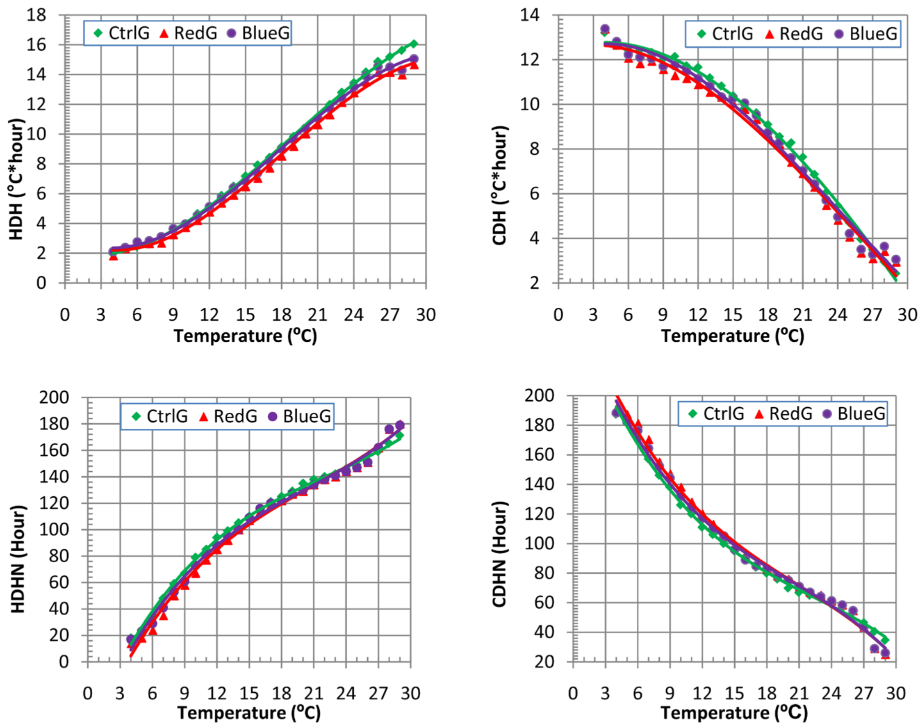

Figure 1. HDH, CDH, HDHN and CDHN Values of Seed and Germination Period

Heating and cooling degree values along with heating and cooling degree-hour values were calculated and plotted according to the suggested temperature values for the seedling stage which is the second growth stage for the lettuce plant (Figure 2). It was determined when the values at this stage were examined that the CtrlG values are greater than both RedG and BlueG values during this growth stage as well. It can again be stated for this growth stage that the use of colored cover material is more advantageous with regard to energy requirement values with temperature in comparison with the control greenhouse.

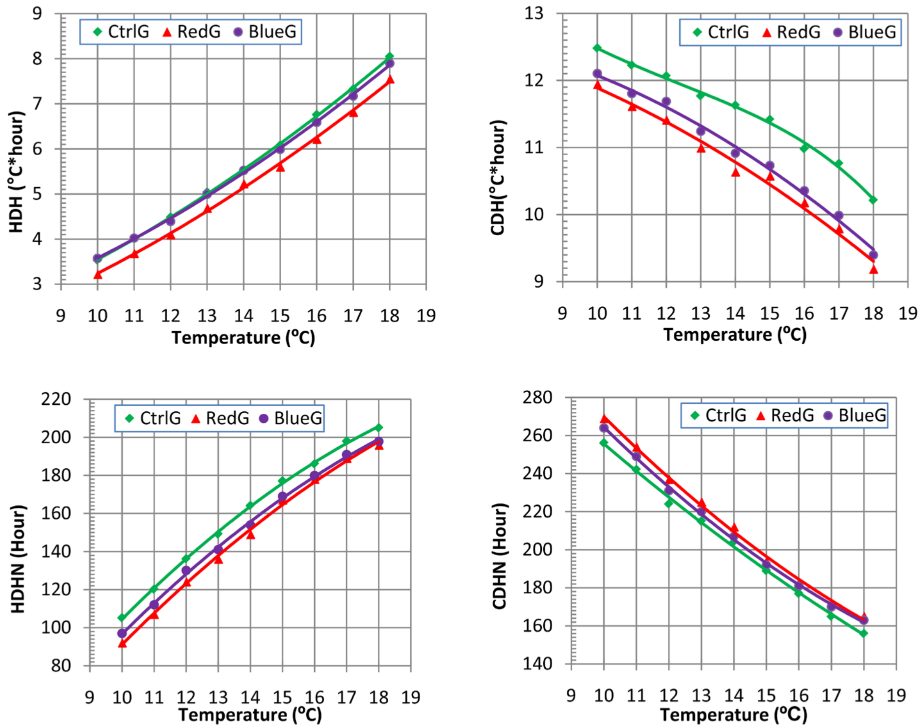

Figure 2. HDH, CDH, HDHN and CDHN Values of Seedling Period

It was determined that the CDHN value is high for RedG, whereas the HDH, CDH, and HDHN values are high for CtrlG during the growth stage of the lettuce plant (Figure 3). Since the values for CtrlG are high save for CDHN, it can be put forth that the use of colored greenhouses for lettuce growth during this growth stage will be advantageous with regard to temperature and energy requirements.

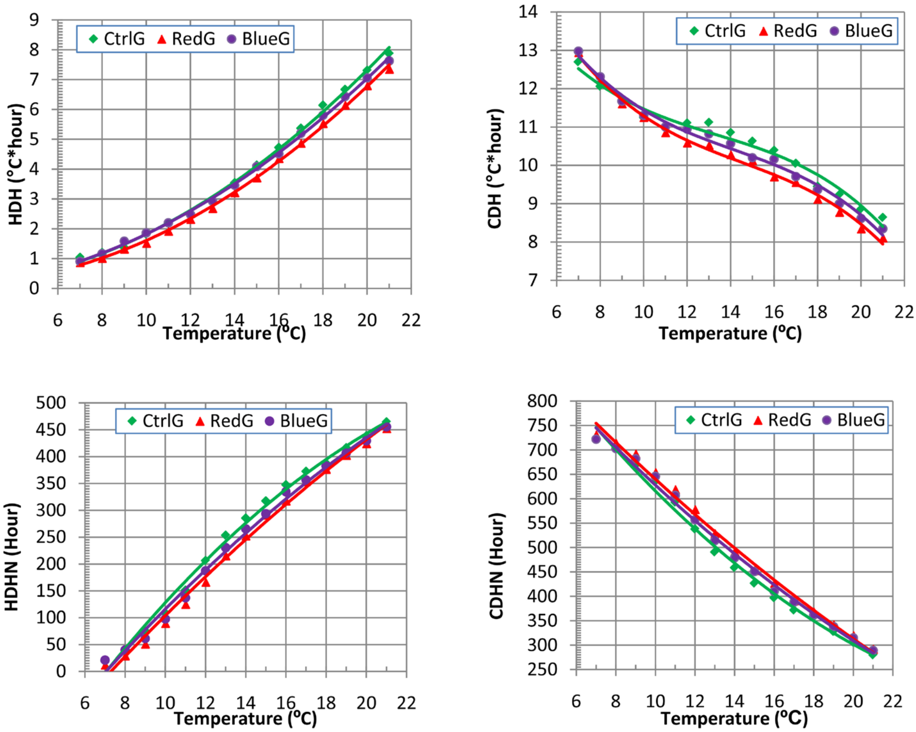

Figure 3. HDH, CDH, HDHN and CDHN Values of Growing Period

It was determined that only the CDHN value is high for RedG in comparison with the CtrlG during the harvesting and jointing stages for the lettuce plant which is the final growth stage and that CtrlG values are high with regard to HDH, CDH, and HDHN (Figure 4). It can again be put forth for this growth that the use of colored cover material will be beneficial with regard to temperature values and energy requirements.

Determining the heating and cooling values at greenhouses where energy consumption takes place is important for energy requirements. Because these values directly increase energy costs. Our greenhouses cannot be heated especially during the winter periods due to the high costs involved with heating and cooling and heating can only be made as a protection against frost. Researchers indicate that it has indirect impacts on product yield and amount (Çolak 2002, Ertop and Atılgan 2017). A paired sample t-test was applied during the study in order to determine whether there are any statistically significant differences between the HDH, CDH, HDHN and CDHN values calculated for CtrlG and the HDH, CDH, HDHN and CDHN values calculated for RedG and BlueG greenhouses. Moreover, coefficients of variation were calculated for determining the best cover color among CtrlG and other greenhouses (Table 2).

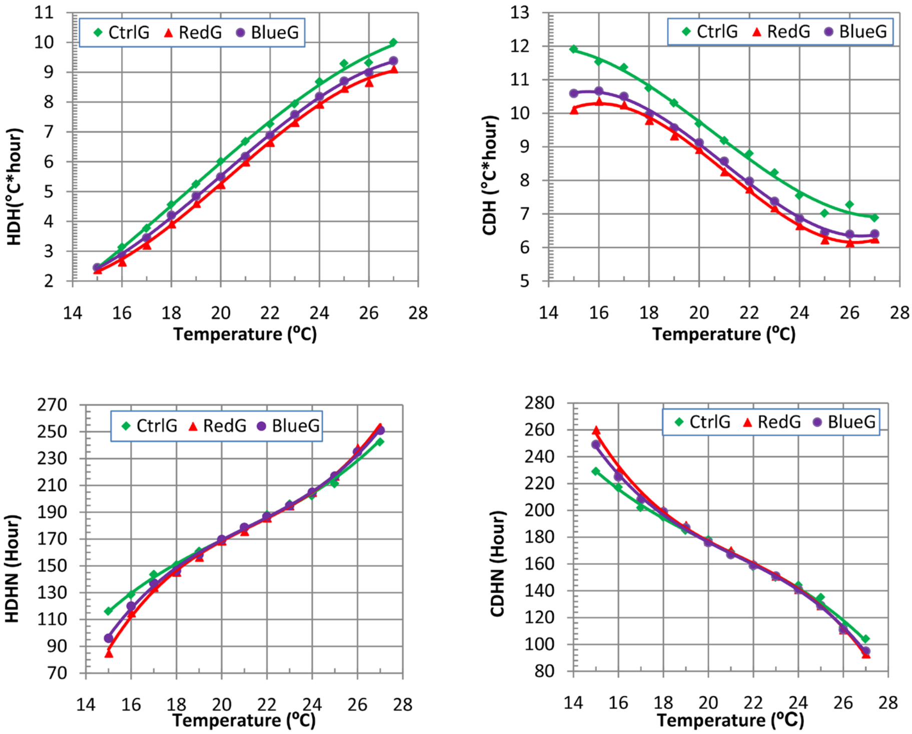

Figure 4. HDH, CDH, HDHN and CDHN Values of Jointing and Harvest Period

Table 2. Paired Sample t Test between Means of HDH, CDH, HDHN and CDHN Values

Greenhouse Type	Paired Sample *t* Test		Coefficient of Change (%)	
	$T_{Calculated}$	t_{Table}	$CC_{calculated}$	Result
	CtrlG		CtrlG	
HDH (°C*hour)				
Seed and Germination Period				
RedG	19,700	± 1,98393	6,682	Homogeneous
BlueG	8,392		3,421	
Seedling Period				

Greenhouse Type	Paired Sample *t* Test		Coefficient of Change (%)	
	$T_{Calculated}$	t_{Table}	$CC_{calculated}$	Result
	CtrlG		CtrlG	
RedG	83,168	± 1,97767	7,467	Homogeneous
BlueG	17,382		1,365	
Growing Period				
RedG	57,604	± 1,96828	9,885	Homogeneous
BlueG	19,330		4,219	
Jointing and Harvest Period				
RedG	55,419	± 1,97801	9,963	Homogeneous
BlueG	43,430		6,208	
HDHN (Hour)				
Seed and Germination Period				
RedG	9,638	± 1,98393	8,508	Homogeneous
BlueG	6,718		4,562	
Seedling Period				
RedG	88,608	± 1,97767	7,690	Homogeneous
BlueG	114,865		5,039	
Growing Period				
RedG	56,581	± 1,96828	14,102	Homogeneous
BlueG	44,073		6,486	
Jointing and Harvest Period				
RedG	5,970	± 1,97801	4,867	
BlueG	4,256		3,395	Homogeneous
CDH (°C*hour)				
Seed and Germination Period				
RedG	15,679	± 1,98393	6,221	
BlueG	8,972		4,370	Homogeneous
Seedling Period				
RedG	87,280	± 1,97767	7,067	
BlueG	65,828		5,233	Homogeneous
Growing Period				
RedG	30,410	± 1,96828	3,798	
BlueG	17,302		2,048	Homogeneous
Jointing and Harvest Period				

Greenhouse Type	Paired Sample *t* Test		Coefficient of Change (%)	
	$T_{Calculated}$	t_{Table}	$CC_{calculated}$	Result
	CtrlG		CtrlG	
RedG	66,275	± 1,97801	10,992	
BlueG	67,164		8,364	Homogeneous
CDHN (Hour)				
Seed and Germination Period				
RedG	– 9,749	± 1,98393	5,011	
BlueG	– 6,854		3,632	Homogeneous
Seedling Period				
RedG	– 89,676	± 1,97767	5,650	
BlueG	– 115,981		3,835	Homogeneous
Growing Period				
RedG	– 56,760	± 1,96828	4,723	
BlueG	– 44,153		2,856	Homogeneous
Jointing and Harvest Period				
RedG	– 5,949	± 1,97801	3,905	
BlueG	– 3,558		3,012	Homogeneous

It was determined based on the values presented in Table 2 that the HDH, CDH, HDHN and CDHN average values vary between – 115,981 and – 3,558 among the control greenhouse and greenhouses with different colored cover materials. In addition, it was also determined that the $t_{Calculated}$ values are greater than t_{Table} values for all growth stages indicating that the HDH, CDH, HDHN, and CDHN average values are similar for the control greenhouse and greenhouses with different colored cover materials at a significance level of 5% (homogeneous). However, the blue colored greenhouse displayed a greater homogeneity with the control greenhouse in comparison with the red greenhouse.

It was determined based on the coefficients of variation (Table 2) results that the HDH, CDH, HDHN and CDHN average values vary between 1,365% and 14,102%. It was also put forth that the homogeneity between CtrlG and BlueG is greater (1,365% – 8,364%) but that RedG (3,798% – 14,102%) is less at a significance level of 5%. Regression analysis was carried out as part of the study between the HDH, CDH, HDHN and CDHN values (independent variable) at a significance level of 5% calculated based on the different base temperature values (T_b) for lettuce growth stages in three greenhouses with different cover material. Coefficients calculated for different lettuce growth stages and statistical characteristics are presented in Table 3.

Table 3. General Equation Coefficients and Statistical Properties Developed for HDH, CDH, HDHN and CDHN (For Seedling and Growing Period $Y = a + b.T + c.T^2$, For Seed, Germination, Jointing and Harvest Period $Y = a + b.T + c.T^2 + d.T^3$)

Greenhouse Type	Equation Coefficients				r	s	$F_{Calculated}$	p (<0.05)
	a	b	c	d				
HDH (°C*hour)								
Seed and Germination Period								
CtrlG	2,316	– 0,2217	0,05009	– 0,000889	0,999	0,122623	12393,45	0,000
RedG	3,283	– 0,5207	0,06818	– 0,001261	0,999	0,224526	3203,63	0,000
BlueG	3,247	– 0,4678	0,06625	– 0,001242	0,999	0,213899	3608,27	0,000
Seedling Period								
CtrlG	0,6855	0,1342	0,01520		0,9999	0,0342501	8041,39	0,000
RedG	0,4837	0,1331	0,01423		0,999	0,0689186	1791,61	0,000
BlueG	1,049	0,09597	0,01569		0,9999	0,0500307	3449,72	0,000
Growing Period								
CtrlG	0,0834	– 0,01427	0,01881		0,999	0,121555	2537,23	0,000
RedG	0,1634	– 0,04175	0,01862		0,999	0,0760616	5689,06	0,000
BlueG	– 0,0376	0,01797	0,01680		0,999	0,0808692	5192,12	0,000
Jointing and Harvest Period								
CtrlG	3,610	– 1,240	0,1059	– 0,001902	0,999	0,118356	1814,3	0,000
RedG	26,11	– 4,470	0,2549	– 0,004175	0,999	0,0762702	3863,50	0,000
BlueG	19,09	– 3,438	0,2065	– 0,003428	0,9999	0,0554353	7530,70	0,000
HDHN (Hour)								
Seed and Germination Period								
CtrlG	– 50,91	18,48	– 0,6645	0,009947	0,999	2,01189	4065,03	0,000
RedG	– 59,83	18,59	– 0,6720	0,01074	0,996	4,28443	1072,27	0,000
BlueG	– 55,89	18,90	– 0,7170	0,01175	0,997	3,83939	1239,06	0,000
Seedling Period								
CtrlG	– 118,6	27,66	– 0,5352		0,999	1,10996	3945,77	0,000
RedG	– 123,0	25,91	– 0,4489		0,999	2,09124	1227,50	0,000
BlueG	– 119,7	26,54	– 0,4906		0,999	1,51560	2157,70	0,000
Growing Period								
CtrlG	– 373,7	59,51	– 0,9337		0,997	11,9574	1102,58	0,000
RedG	– 311,9	45,96	– 0,4386		0,997	12,4098	1033,42	0,000
BlueG	– 318,1	49,13	– 0,5732		0,997	12,2351	1027,97	0,000
Jointing and Harvest Period								

Greenhouse Type	Equation Coefficients				r	s	$F_{Calculated}$	p (<0.05)
	a	b	c	d				
CtrlG	– 620,7	99,30	– 4,415	0,07122	0,998	2,90876	706,40	0,000
RedG	– 1519,0	222,4	– 10,04	0,1569	0,999	2,38375	1633,00	0,000
BlueG	– 1213,0	180,2	– 8,096	0,1271	0,999	1,61852	3100,74	0,000
CDH (°C*hour)								
Seed and Germination Period								
CtrlG	12,46	0,1676	– 0,02292	0,000168	– 0,998	0,196647	2507,93	0,000
RedG	12,43	0,1525	– 0,02701	0,000336	– 0,993	0,404784	567,58	0,000
BlueG	12,21	0,2491	– 0,03328	0,000454	– 0,994	0,374748	633,12	0,000
Seedling Period								
CtrlG	11,02	0,3416	– 0,2130		– 0,996	0,073233	305,87	0,000
RedG	11,93	0,1500	– 0,01650		– 0,992	0,119746	159,67	0,000
BlueG	12,03	0,1735	– 0,01756		– 0,995	0,093134	275,78	0,000
Growing Period								
CtrlG	18,89	– 1,468	0,09676	– 0,002410	– 0,988	0,200231	156,70	0,000
RedG	21,78	– 1,997	0,1229	– 0,002820	– 0,997	0,113618	695,67	0,000
BlueG	21,10	– 1,839	0,1153	– 0,002704	– 0,995	0,142548	399,20	0,000
Jointing and Harvest Period								
CtrlG	– 15,61	4,791	– 0,2607	0,004229	– 0,997	0,153037	552,13	0,000
RedG	– 51,99	9,769	– 0,4915	0,007760	– 0,999	0,0745972	1933,28	0,000
BlueG	– 41,13	8,273	– 0,4221	0,006697	– 0,999	0,0780238	1857,41	0,000
CDHN (Hour)								
Seed and Germination Period								
CtrlG	265,5	– 18,51	0,6619	– 0,009821	– 0,999	2,04315	3951,73	0,000
RedG	265,8	– 18,73	0,6791	– 0,01084	– 0,996	4,42413	1007,10	0,000
BlueG	261,9	– 19,07	0,7250	– 0,01187	– 0,997	3,97319	1158,87	0,000
Seedling Period								
CtrlG	479,6	– 27,61	0,5325		– 0,999	1,10116	4026,51	0,000
RedG	483,4	– 25,80	0,4448		– 0,999	2,07009	1254,79	0,000
BlueG	480,0	– 26,42	0,4859		– 0,999	1,49877	2210,00	0,000
Growing Period								
CtrlG	1113,0	– 58,94	0,9171		– 0,997	11,9651	1102,83	0,000
RedG	1052,0	– 45,41	0,4236		– 0,997	12,3170	1041,33	0,000
BlueG	1058,0	– 48,56	0,5571		– 0,997	12,1396	1029,88	0,000
Jointing and Harvest Period								

Greenhouse Type	Equation Coefficients				r	s	$F_{Calculated}$	p (<0.05)
	a	b	c	d				
CtrlG	952,2	– 97,43	4,331	– 0,06993	– 0,998	2,69599	810,40	0,000
RedG	1872,0	– 223,6	10,09	– 0,1576	– 0,999	2,05849	2129,49	0,000
BlueG	1558,0	– 180,4	8,114	– 0,1275	– 0,999	1,65389	2922,53	0,000

It was observed when the results for the developed equations were examined with regard to r, F and p values at a significance level of 5% that the correlation coefficients for HDH, CDH, HDHN, and CDHN of all greenhouses vary between – 0,988 (98,8%) and 0,9999 (99,99%). It has been determined that the developed equations can be explained statistically for lettuce growth only by temperature values, but that the portion between 0,0001 (0,01%) and 0,012 (1,2%) cannot be explained. It was also concluded that the unexplained portion may be due to factors such as meteorological variables, research flaws or agricultural activities.

CONCLUSIONS

Heating and cooling degree-hour values and numbers were calculated during the present study for lettuce growth in greenhouses with three different cover materials. It was concluded that the use of colored cover material will be more beneficial with regard to energy requirement calculated based on the heating and cooling values in calculated by taking into consideration the heating and cooling values for each growth stage of lettuce plant. Coefficients of variation were calculated for determining the homogeneities between different data sets by comparing the values calculated for the green and blue greenhouses based on the control greenhouse. It was determined that the HDH, CDH, HDHN, and CDHN average values for the control greenhouse and greenhouses with different colored cover materials vary between 1,365% and 14,102%. Thus, it was concluded that the blue colored greenhouse is (1,365%-8,364%) more homogeneous in comparison with the control greenhouse but that the PE greenhouse with red cover is less homogeneous (3,798%-14,102%) at a significance level of 5%.

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Received: 16.09.2019
Accepted: 14.10.2019