A Study on Determination of Optimum Ventilation Openings in Greenhouses Using by the Decision Tree Method

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Abstract

In the greenhouses, optimum climate conditions are depends on proper ventilation openings and the number of repetitions of ventilation. These conditions are performed by the climate control systems in the modern greenhouses.
The climate control systems operate according to some control and classification models such as decision tree. The decision tree method is commonly used in operations research, specifically in decision analysis, to help identify a strategy most likely to reach a goal. In this study, optimum ventilation opening ratio and the numbers of its position calculated and determined for a glass greenhouses by using the decision tree method and the results were discussed.

Key words: Decision tree method, greenhouse, climate control, ventilation opening ratio

1. Introduction

Natural ventilation is mostly used as a main control method of the greenhouse's high temperatures and relative humidity. It requires less energy, equipment and power than other forms of ventilation. The experimental investigations of the air exchange through the openings are very useful to clearly picture the air movement around the greenhouse and are thus helpful for designers to provide optimal ventilation systems and mechanisms.
Ventilation mechanisms are quite complex and remain poorly understood. Since neural network models are very flexible, they may be as an initial screening tool employed preparatory to physical modelling. They allow marginally useful inputs to be identified and thus help in reducing the number of relevant variables implicated. Furthermore, differences between the degree of fit of the physical and neural network models are one measure of the physical understanding underlying the model (Seginer et al., 1994).
Detecting the ventilation need and obviating it can be provided at the desired level via computer controlled or microcomputer based systems which operate according to the specific methods. These climate control systems are used to whole control processing such as fuzzy logic, PID, feed - forward, etc. A climate control computer checks regularly whole climatic elements and runs window motors during the natural ventilation. These control methods use some decision analysis. Decision analysis includes many procedures, methods, and tools for identifying and clearly representing. In decision analysis, a "*Decision Tree Method"* is used as a visual and analytical decision support tool, where the expected values (or expected utility) of competing alternatives are calculated.
A decision tree is a decision support tool that uses a tree-like graph or model of decisions and their possible consequences, including chance event outcomes, resource costs, and utility. It is one way to display an algorithm. If in practice decisions have to be taken online with no recall under incomplete knowledge, a decision tree should be paralleled by a probability model as a best choice model or online selection model algorithm. Another use of decision trees is as a descriptive means for calculating conditional probabilities. The decision tree method is commonly used in operations research, specifically in decision analysis, to help identify a strategy most likely to reach a goal (Yang, 2006)

In this paper, an appropriate openings level for ventilation is determined using decision tree method for a wide screen type glass greenhouse. The optimum ventilation openings rates, counts of repetitions the openings were calculated and presented at five different intervals for one day. The influences of the temperature and relative humidity were determined on ventilation openings and the results were discussed.

2. Material and Method

In this study, a wide screen type greenhouse has been employed which exists in Antalya, Turkey. The greenhouse consists of totally 39 spans of 8 m width and 24 sections of 4.5 m maximum length which have totally 31752 m^2 surface areas. Greenhouse has been positioned in the north-south direction and has only top ventilations, which can be opened in east and west directions. The measurements of ventilation have been indicated in Fig. 1.

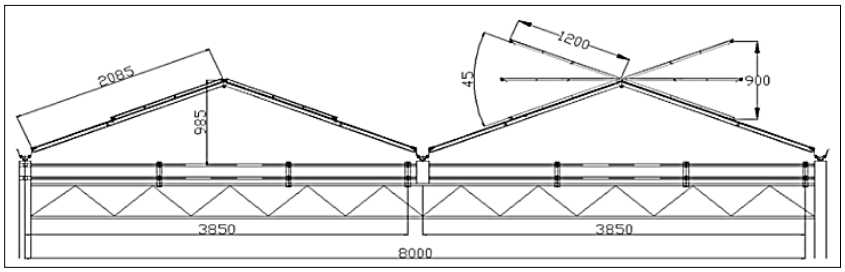


FIGURE 1: Wide screen type greenhouse

In the greenhouse, vegetable plants are grown. Vegetable plants can suffer by the cold or extreme conditions easily when the temperature and relative humidity falls or increases extremely. Daytime internal temperature of greenhouse should not exceed more than 28°C (Bass, 1996). Problems can arise about bearing and color formation of plant at the temperatures over than 30°C, while insemination problems can arise at the temperatures under 10°C. The desired ambient temperature is provided out of these values. The desired humidity value must not be exceeding 70-85% for insemination. Therefore, while constituting the decision tree, it has been foreseen to hold the temperature 11-28°C and relative humidity between 35-85%. The indoor condition data have been divided to five level (for temperature: <11°C, 11-16°C, 16-22°C, 22-28°C and 28°C<; for relative humidity: <35%, 35-50%, 50-70%, 70-85% and 85%<). The temperature and relative humidity data were obtained for May 2011 by the records in the climate computer of the greenhouse.

Decision trees can solve many problems which are practically important and to express the given information stuck more systematically. Here, there are three main units: "*Node, Branch and Leaf".* Nodes denote questions, branches denote the answers and leaves denote the decision class. So, questions begun to ask with the first node of the tree and this continues till leaves or the nodes which are without any branches. It is easy to explain the decision tree with rules like *if-then* structures. Number of the rules is same as number of the leaves on the advanced point (Ozkan, 2008). It is important to select the initial attribute for branching while forming the decision tree. Most of the constituted algorithms must initially try to form the tree by estimating some values and to make acceptations. For this purpose, "entropy" is used. Branching of the tree is formed according to the entropy values. In this study, ID3 algorithm has been employed among the classification based algorithms. In ID3 algorithm, probability can be explained in equation (1) as follows:

$$P_i = \frac{\mathrm{C_i}}{\mathrm{T}} \qquad (1)$$

Here, C_i denotes the values which class attribute will get, T denotes the set values which produces the class values and P_{it} denotes the probability distribution of the classes. The following equation (2) is used in order to estimate the entropy:

$$H(T) = -\sum_{i=1}^{n} p_i \log_2(p_i) \quad (2)$$

The constructed algorithm by this method provide information about the operation bases of a climate control system and gives a hint about importance level of the parameters like temperature and humidity according to the desired climate conditions. Five different levels have been determined between 0-100% for ventilation.

3. Results

In order to obtain well results, while estimating the right positions of ventilations, effective and time dependent climate values have been determined in Table 1. Here, narrow (N=10/30), very narrow (VN=10/30) medium (M=3/30), wide (W=0/30), very wide (VW=17/30) and full open (F=0/30). The openings of ventilation are accepted as the absolute close (0%) and full open (100%). Each step in openings of the ventilations is 20%. According to this, the window opening height increase about 0.18 m in each step (maximum window opening height is 0.90 m). It appears that, the temperature is decrease to 3-4°C for each openings level.

TABLE 1. The openings rates for greenhouse ventilations. *(0%=Close (C); 0-20%=Very Narrow (VN); 20-40%=Narrow (N); 40-60%=Medium (M); 60-80%=Wide (W); 80-100%=Very Wide (VW); 100%=Full Open (F).*

Temperature (°C)	Relative Humidity (%)				
	<35	35-50	50-70	70-85	85<
<11	C	C	C	C	VN
11-16	C	C	C	VN	N
16-22	N	N	N	N	M
22-28	M	M	W	VW	VW
28<	W	W	VW	F	F

Entropy value for ventilation openings is H_{window}=1.325. Entropy is calculated both temperature and relative humidity for T1 and temperature has been calculated as first priority climatic factor. In this instance, normal temperature and high temperature repetition counts are 13 and 17 for 30 days in May respectively. According to temperature (H_{temp}), entropy has been calculated as 0.337. Accordingly, gain for temperature is 0.988 ($H_{window} - H_{temp}$). On the other hand, both high humidity and very high humidity repetition counts are 15. In this instance, entropy value is obtained for relative humidity as 0.8195. Gain for relative humidity is 0.5008 (Table 2).

TABLE 2. Results of entropy between T1 and T5

Variables	Results of Entropy According to Between T1 and T5				
	T1	T2	T3	T4	T5
Ventilation	1.325	1.870	1.597	1.820	1.950
Temperature	0.337	0.724	0.766	1.140	0.642
Relative Humidity	0.8195	1.511	0.889	0.922	1.602
Gain for Temperature	0.988	1.146	0.831	0.680	1.308
Gain for Relative Humidity	0.5008	0.359	0.708	0.898	0.348
Determinant Variable	Temperature	Temperature	Temperature	R. Humidity	Temperature

The ventilation openings rate has been determined for five periods depending on the average climate data at 07.00-10.00 (T1), 10.00-13.00 (T2), 13.00-15.00 (T3) and 15.00-17.00 (T4) and 17.00-19.00 (T5) (Fig. 2)

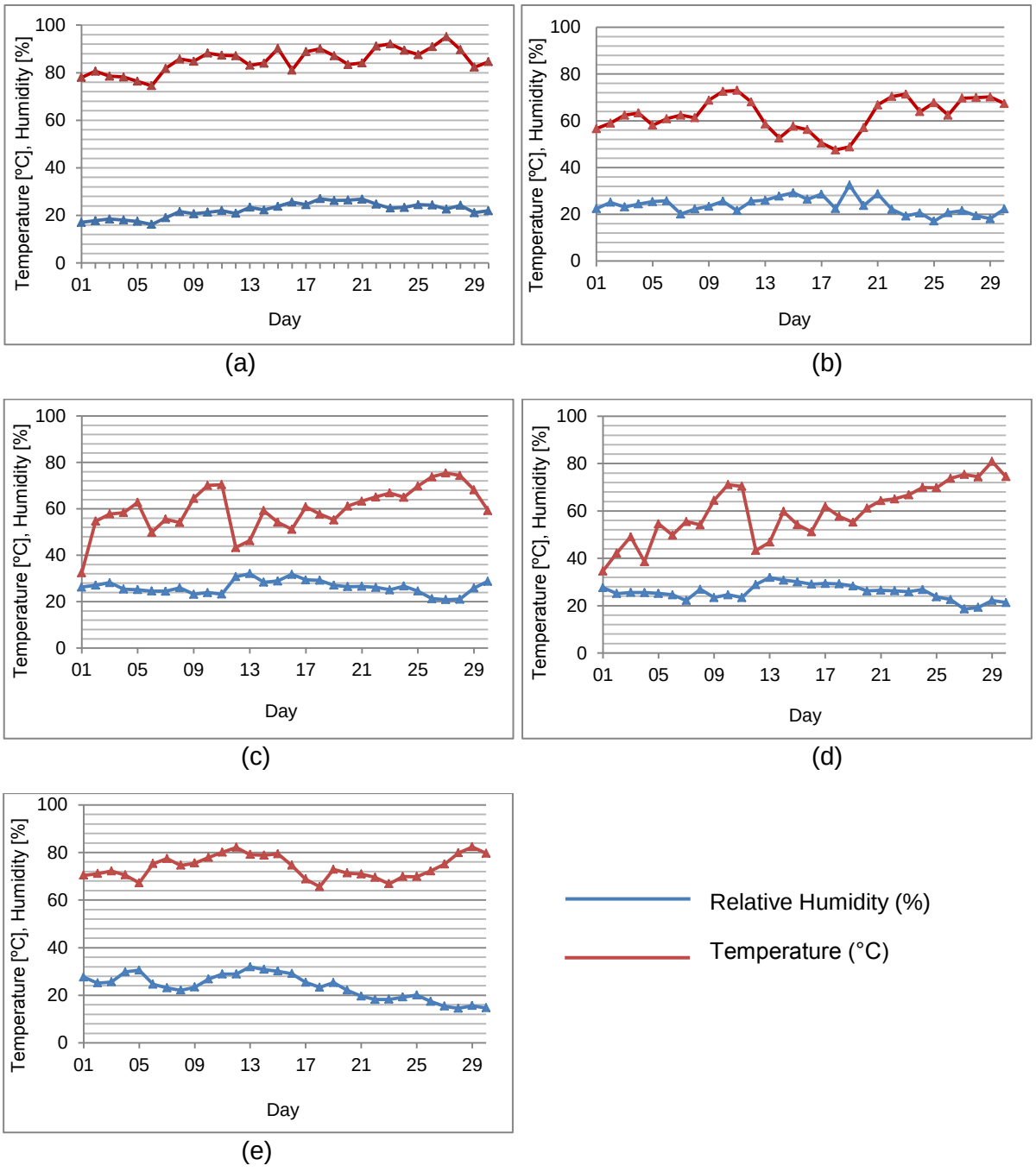


FIGURE 2. The Average temperature and relative humidity data obtained from the greenhouse depending on five periods in one day; (a) T1, (b) T2, (c) T3, (d) T4, (e) T5.

When the estimated results are investigated, the highest entropy has been obtained as 1.950 at 17.00-19:00 (T5). T2 (1.870) and T4 (1.820) follow T5, respectively. The results show that no significant difference between the values of entropy. However, entropy values at T1 (1.325) and T3 (1.597) are less than T5, T4 and T2. This situation means that, ventilation openings counts and rates at T5, T4 and T2 are more important than the others, respectively. On the other hand, temperature has a very important role to change the ventilation position. But, it appears that relative humidity level is too high at T4 and hence, relative humidity has

the primary importance while temperature is having the secondary importance. At T2, if relative humidity is not in comfort zone for plants (%85<), the ventilations always are closed as the temperature is low. The results of repetition counts for ventilations were shown in Table 3.

TABLE 3. Repetition counts of ventilation openings between T1 and T5.

Time	Repetition Counts of Ventilation Openings	Temperature	R. Humidity	Ventilation Openings Rate
T1	12	H	VH	VW
	5	H	H	VW
	3	N	VH	M
	10	N	H	N
T2	1	L	N	C
	1	N	H	VW
	1	H	L	M
	2	H	H	VW
	6	VH	N	VW
	2	N	H	N
	5	N	N	N
	11	H	N	W
	1	VH	L	W
T3	1	H	VL	M
	1	H	L	M
	14	VH	N	VW
	2	H	H	VW
	3	N	H	N
	7	H	N	W
	2	H	L	W
T4	1	H	VL	M
	4	H	L	M
	10	H	N	W
	4	H	H	VW
	6	H	N	VW
	3	N	H	N
	2	VH	L	W
T5	10	H	H	VW
	7	VH	H	F
	2	H	N	W
	1	VL	N	VW
	2	N	H	W
	4	N	N	W
	4	L	H	VN

Fig. 3 shows the constructed decision tree for ventilation by considering inside climate parameters of the greenhouse. According to average values of temperature and relative humidity, most repetition counts for openings is occurred in (VW) in one day (T4 except). Otherwise, full open position of windows (F) is occurred only at T5 and as 7 repetition counts. Full closed position of windows (C) is occurred only at T2 and as 1 repetition count only.

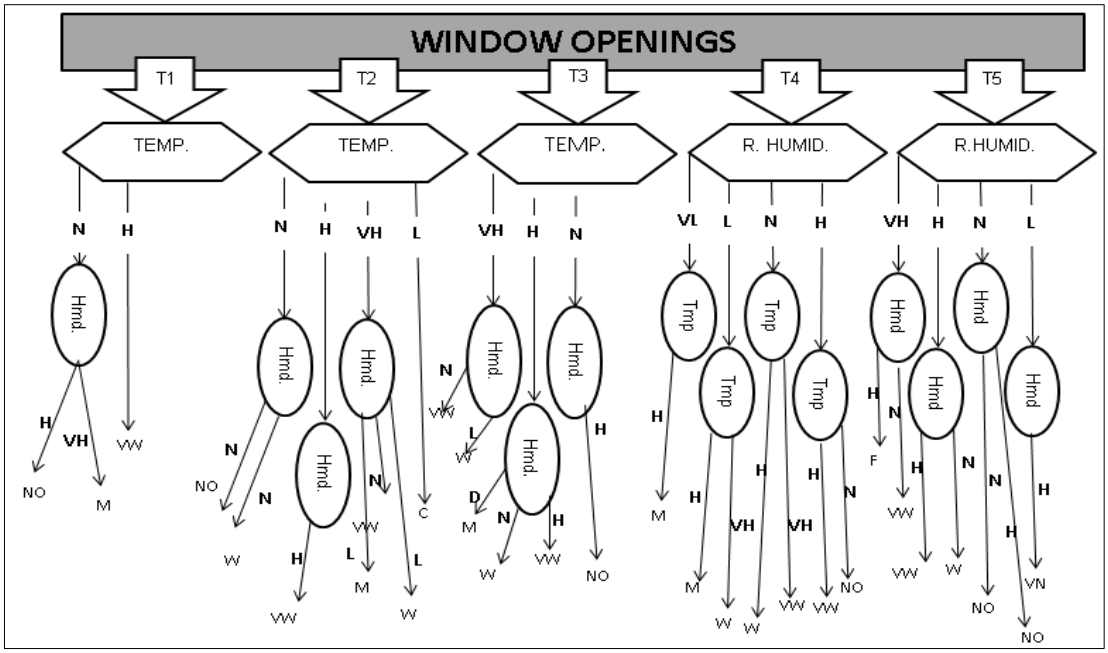


FIGURE 3. The constructed decision tree for ventilation by considering inside climate parameters of the greenhouse (levels of ventilation openings between 0-100%).

4. Conclusion

In this study, decision tree method given hints about some actions of the ventilation system in one day. These obtained data can advise to choose the elements of ventilation mechanism (electric motor, rack type, gear system, etc.). Although further modification is required, the method can provide a useful means to implement new environmental control strategies and structures for open-roof greenhouses.

The climate conditions in a greenhouse can be provided by optimum openings levels of ventilations. If the fluctuations on greenhouse ventilations, such as the openings rates and their repetition counts, are set properly according to climate conditions and place, the indoor conditions can be arranged easily. Therefore, in the greenhouses with well-designed natural ventilation mechanism often provide very comfortable and pleasant environments for the plants. These systems are integrated into greenhouse systems where there is some mechanical support. The ventilation mechanisms are quite complex and co-ordination is very important between the ventilation elements in a greenhouse. If their work is not proper they can be damaged. In this way, the automatic control systems and mechanic components can be well planned by using decision tree method to develop before greenhouses were not built and fatal errors can be prevented.

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