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The Impact of Yucca (*Yucca Elephantipes* Regel) on the Amount of Indoor CO_2 Depending on Temperature

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Abstract: Today; at least 80% of human life passes in closed areas and the indoor air quality directly affects the health and performances of human beings. Especially when CO_2 raises above a certain level, it causes to various disorders such as headache, dizziness, fatigue, concentration disorders, throat and nose irritations, nasal flow, cough and ocular flow. The most important factor affecting the indoor CO_2 amount is the metabolic activities of the living. The amount of CO_2 increasing with respiration decreases with photosynthesis. Therefore; plants could be used in indoors for the purpose of decreasing the CO_2 amount. However; because there is no sufficient information in this issue, the plants cannot be efficiently and consciously used in the issue of decreasing the CO_2 amount in indoors.it has been aimed to determine the change of the impact of yucca (*Yucca elephantipes* Regel) which is one of the plants most frequently used as an indoor decoration plant on the indoor CO_2 amount depending on temperature. As a result of the study; it has been determined that the respiration made by yucca in dark environment is at an insignificant level depending on temperature. However; it has also been determined that it shows the highest impact in the temperatures 23-24 °C, its speed of photosynthesis at 30 °C is lower than that of 20 °C but higher than that of 15 °C in the environment in which there is light.

Key words: Yucca; *Yucca elephantipes* Regel; CO_2; Air quality

INTRODUCTION

The rapid change process experienced in the world causes to the destruction of nature, pollution of air, water and soil and the distortion of ecological balance[1-3]. In addition; industrializing world has forced people to live in closed areas and today, at least 80% of human life has started to pass in closed areas[4-5].

The amount of CO_2 rapidly changes as a result of the metabolic activities of human beings in indoors in which the majority of human life passes and the increasing CO_2 amount directly affects the health and performances of human beings. Fatigue, absence of perception and state of sleep occur as a result of the increase in the amount of carbon dioxide in the environment. CO_2 causes to various complaints giving rise to performance losses and whose reasons cannot be easily determined. When CO_2 amount in the environment increases above 1000 ppm; headache, dizziness, fatigue, absence of concentration and odor disorders occur; when it increases above 1500 ppm, throat and nose irritation, nasal flow, cough and ocular flows occur[6]. However; the conducted studies show that indoor CO_2 amount is far beyond these levels and also, it exceeds 4000 ppm at schools and 3000 ppm in exam halls [4,7].

The most efficient way to decrease the indoor CO_2 amount is the ventilation of the environment. However; the environment cannot be ventilated for a long time for the purpose of not decreasing the heat of the environment in winter in which especially the CO_2 amount is an important problem; and this situation causes to significant decrease in the quality of the air due to the increase in CO_2 amount[5]

Another factor affecting indoor CO_2 amount is the plants grown indoors. Plants are used for the purpose of photosynthesizing the carbon dioxide in the environment and they give oxygen to the environment[8-9] However; photosynthesis is dependent on the factors such as light and temperature in the environment and when the necessary conditions do not occur, plants aspirate, take oxygen from the environment and give carbon dioxide to the environment.

Therefore; it is necessary to determine the impact of the plants on the indoor air quality in accordance with the conditions of the environment. One of these most important conditions is temperature. Temperature is one of the most important factors affecting the photosynthesis speed of the plants and therefore, the impact level on the CO_2 amount in the environment. For this reason; the use of plants in an efficient way for the purpose of increasing the indoor air quality is possible only with the determination of plant-temperature relation and growing the plants in convenient temperature degrees. In this study; it has been aimed to determine and formulize the impact of yucca being one of most preferred indoor plants of the world as a decoration plant on the CO_2 amount depending on temperature.

MATERIALS AND METHODS

Material: The study has been carried out on yucca (*Yucca elephantipes* Regel) frequently used as indoor decoration plant. The genus Yucca (Agavaceae) contains about 35–40 species, which are mainly distributed in Central and Northern America. Many of them as ornamental plants are commonly cultivated in the tropical gardens of the World. Yucca extracts are used not only to feed livestock and poultry to improve their growth and productivity, but also to reduce ammonia and odors in poultry excreta on farms[10]. Yucca is one of the most preferred species as an indoor decoration plant[11].

Method: The study has been carried out in a plant growing cabinet having no air exchange with the outdoor, whose light and temperature conditions could be determined, whose internal volume is known and which is independent from the outdoor. A measurement device that could transfer the data of the plant to the computer by conducting CO_2, temperature and humidity measurements regularly together with the plant has been installed in the plant growing cabinet.

The brand of the plant growing cabinet in which the ambient conditions could be formed is "Jaiotech GC 300". Because the study is based on the principle of absolute impermeability, the air impermeability has been tested within the cabinet, a glass cabinet has been placed and "Extech Desktop Indoor Air Quality CO_2 Datalogger" measurement device has been placed inside this cabinet. Afterwards; the plant has been placed in the cabinet and the CO_2 amount has been adjusted as 2.000 ppm ± 10%.

The plants prepared for the measurements have been placed in the cabinet and the measurement order of the cabinet has been adjusted as follows:

- 12 hours at 15 °C temperature and 20.000 lux light,
- 12 hours at 15 °C temperature dark environment,
- 12 hours at 20 °C temperature and 20.000 lux light,
- 12 hours at 20 °C temperature and dark environment,
- 12 hours at 25 °C temperature and 20.000 lux light,
- 12 hours at 25 °C temperature dark environment,
- 12 hours at 30 °C temperature and 20.000 lux light,
- 12 hours at 30 °C temperature dark environment,
- 12 hours at 35 °C temperature and 20.000 lux light,
- 12 hours at 35 °C temperature dark environment,

The device has been adjusted as explained above as the operation system, the plant has been placed in the cabinet inside the device, the measurement device (after such an adjustment that it will conduct measurement once per 5 minutes and it will save the data) which is in the same environment with the plant has been operated and the cabinet has been closed in a way that it will not get any air.

After the completion of the measurement process, the data have been transferred to computer environment and the net volume of the cabinet (by subtracting the pot volume and stem volume of the plant from the cabinet volume) has been calculated. Each plant has remained in the cabinet for 5 days after placement in the cabinet, the device has been operated in the adjustment expressed above during this period, CO_2 measurement device has conducted measurements per 5 minutes and after that, the data have been transferred to computer and evaluated.

The performances of the plants at the end of 1 hour have been taken into consideration in the assessment of the data. The data have been collected by calculating the difference between the CO_2 value at the beginning and CO_2 value at the end of 1 hour. The data have been standardized after the attainment of the data for the purpose of being able to determine how much leaf surface could affect 1 m3 air at what ratio. For instance; while calculating a plant that decreases the CO_2 amount by 157 ppm within 1 hour and that has leaf surface of 0,245 m2 cabinet whose net volume is 0,486 m3 (after subtracting the pot volume); the calculation has been made as "the plant with the leaf surface of 0,486 m2 decreases the CO_2 amount of the area with 1 m3 volume by 157 ppm within 1 hour".

As a result of the study; correlation and regression analyses have been conducted on the data with the help of SPSS 17.0 package program for the purpose of determining the change of the impact of the plant on CO_2 amount depending on temperature in dark and bright environments and the results have been assessed.

RESULTS AND DISCUSION

Regression analysis has been conducted with the help of SPSS package program for the purpose of determining the impact of yucca plant on CO_2 amount in 15, 20, 25, 30 and 35 °C temperatures in dark environment and the results are given in Table 1.

Table 1: The results of the correlation analysis showing the impact of yucca plant on CO_2 amount in dark environment depending on temperature

Equation	Model Summary					Parameter Estimates			
	R^2	F	df1	df2	Sig.	Constant	b1	b2	b3
Quadratic	,292	50,931	2	247	,000	-123,101	13,499	-,273	
Cubic	,286	49,540	2	247	,000	-72,734	6,907	,000	-,004

When the results of **Table 1** are examined; R^2 value has been calculated as 0,292 according to Quadratic analysis results regarding the change of the impact of Yucca plant in dark environment on CO_2 amount depending on temperature and R^2 value has been calculated as 0,286 according to cubic analysis results. R^2 value in here expresses the correlation coefficient and it changes between 0 and -1 or +1 and it determines the direction of the correlation. According to the attained value here, there is a positive and low relation between the temperature in dark environment and the change in CO_2 amount regarding yucca plant.

As a result of the conducted analysis, the graphics showing the relation between the temperature in dark environment and CO_2 amount in yucca plant is given in **Figure 1.**

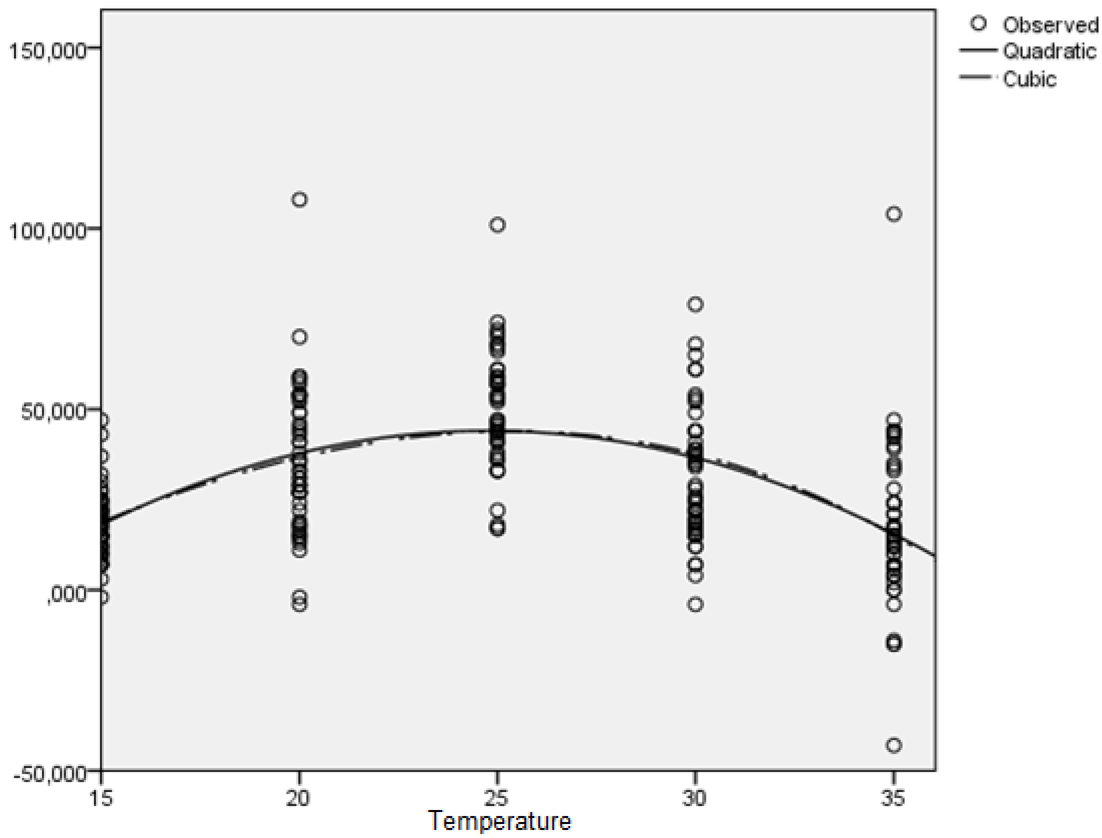

Figure 1: The impact of yucca plant on CO_2 amount depending on temperature in dark environment

Regression analysis has been conducted with the help of SPSS package program for the purpose of determining the impact of yucca plant on CO_2 amount in depending on temperature in the environment with 20.000 lux light and the results are given in **Table 2.**

Table 2: The amount of yucca plant in bright environment on CO_2 amount depending on temperature

Equation	Model Summary					Parameter Estimates			
	R^2	F	df1	df2	Sig.	Constant	b1	b2	b3
Quadratic	,251	41,306	2	247	,000	462,329	-48,111	,996	
Cubic	,224	35,639	2	247	,000	258,863	-22,740	,000	,012

When the results of Table 2 are examined; R^2 value has been calculated as 0,251 according to Quadratic analysis results regarding the change of the impact of Yucca plant in bright environment on CO_2 amount depending on temperature and R^2 value has been calculated as 0,224 according to cubic analysis results. According to the calculated R^2 value, it could be said that there is a positive and low relation between the temperature in bright environment and the change in CO_2 amount in yucca plant as it is in dark environment. As a result of the conducted analysis, the graphic showing the relation between the temperature in dark environment and the change in CO_2 amount in spatiphilium plant is given in Figure 2.

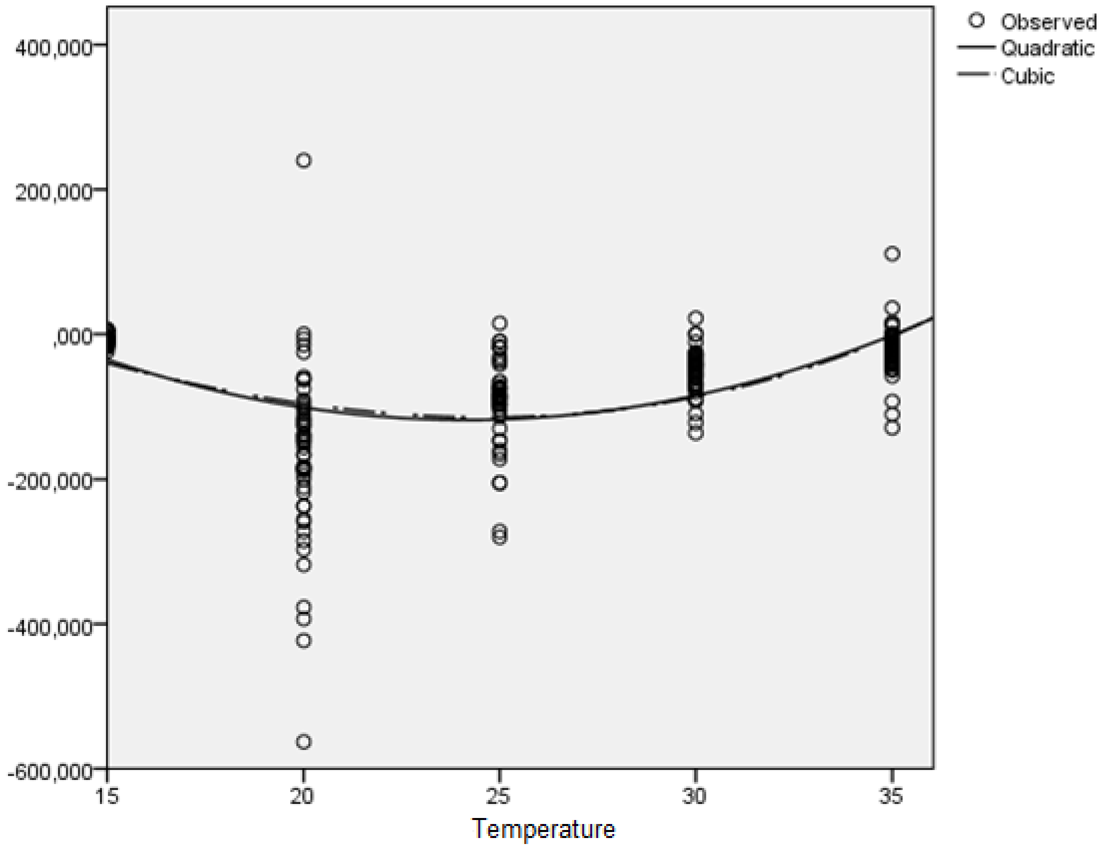

Figure 2: The impact of yucca plant on CO_2 amount depending on temperature in bright environment

The results of the study show that yucca plant affects the CO_2 amount in the environment in different levels depending on temperature; in other words, the speed of photosynthesis changes depending on temperature. When Figure 2 is examined, it could be seen that the impact of yucca on CO_2 amount in the environment draws a reverse bell-shaped curve and it is utmost in 20-25°C temperatures.

The results of the study show that the impact of yucca on CO_2 amount increases depending on temperature, it goes up the highest level at 20-25°C and afterwards, it starts to decrease depending on the increasing temperature, namely it draws a bell-shaped curve. Kacar *et al.*[12] express that the impact of temperature on photosynthesis in the leaves of the plants generally show a curve, the speed of photosynthesis increases until a certain temperature and it rapidly decreases after a certain temperature degree. This situation has also been stated by many researchers[13].

However; the degree of temperature necessary for the speed of photosynthesis at highest level shows changes depending on the plant species. Akman and Guney[14] specify that the temperatures 20-35 °C are the optimum values for photosynthesis and the positive impact of temperature on photosynthesis could continue up to 30 °C. Sevik *et al.*[15] specifies that the impact of the plants on CO_2 amount increases together with the increasing temperature; and the impact of the plants on CO_2 amount starts to decrease after around 25 °C in Ficus, Dieffenbachia and Spatiphilium and after 20 °C in Yucca. It has been detected that Ficus is significantly efficient on CO_2 amount at 35 °C temperature, this impact remains limited in Spatiphilium and Yucca and the plant starts to inhale at 35 °C in Dieffenbachia[15]. The temperature and light demands of the species may show significant differences. For instance; Acarturk [16] expresses that Yucca is a tough species and it requires full sunlight, Spatiphilium does not like direct sunlight, but it likes light, Ficus does not like direct sunlight and it demands minimum 15-18°C. Yucel[17] expresses that Dieffenbachia should be grown in semi-shadow and hot areas which do not get direct sunlight, Spatiphilium should be grown in semi-shadow and hot areas and Yucca should be grown in hot areas and places with abundant sunlight. Dieffenbachia is a plant which could even grow in dark shadow, therefore, whose light demand is too little, which does not like direct sunlight and which could grow better in semi-shadow or indirectly lighted places. It grows well at 20-25 °C in summer and in temperatures which do not go down[18] below 15 °C.

Cetin and Sevik[19] state that *Codiaeum variegatum, Ficus elastica* and *Yucca massengena* could make photosynthesis even in time intervals in which the amount of light is little during the day and decrease the CO_2 amount, *Sinningia speciosa* and *Ocimum basilicum* either increase or do not significantly change the CO_2 amount in the environment under the same light conditions. This situation shows that different plants give different reactions under the same ambient conditions. This situation could be likened to the reactions given by the plants against water or frost stress. In the studies determining the reactions of different species against water stress or frost stress; it has been determined that some plants are significantly damaged under the same stress level and some plants go on their lives with almost no impact [20-22]. Therefore; it is normal for some species to reach the highest photosynthesis speed under different temperature levels.

Plants are the source of life for the living world; they carry out many ecological functions and shape the life in the environments they exist. In the place they grow, plants reduce air pollution, reduce noise, increase aesthetic value, have a positive psychological effect, provide energy conservation, prevent erosion, reduce wind speed and hold the soil with their roots, thus preventing washing away of the soil with rainfalls and streams, and protect wildlife and hunting resources. Open-green areas with plantation are important activity areas for both adults and children[19,23-25].

Such advancement of the plants market made the researchers to be interested in various issues such as defining the distribution areas of plants, protection of plants, cultivation of plants, resistance of plants to stress factors, effects of water and water quality, various areas of use, genetic variability of plants, their relationship with the environment, thus resulting in various studies on these issues[9,26-30].

It has been revealed by many studies that indoor decoration plants could be used for the purpose of decreasing various indoor polluters[31-36]. However; the number of studies conducted to ensure the efficient use of the plants for the purpose of increasing the indoor air quality is too little and the literature information in this issue is too limited. Torpy *et al*.,[37] have examined the potentials of the plants *Aglaonema commutatum, Aspidistra elatior, Castanospermum australe, Chamaedorea elegans, Dracaena deremensis* 'compacta', *Dypsis lutescens, Ficus benjamina* and *Howea forsteriana* for decreasing indoor CO_2 amount and as a result of the study, they have expressed that the plants have a wide variation depending on light conditions. Similar results have also been revealed in other studies[19].

However; the data which have just been attained are not in a sufficient level for the plants to be able to be efficiently used in increasing the indoor air quality. For instance; there are not any studies conducted in the issue of the different variety or forms of the plants. However; the studies conducted on the plants show that different sub-species, variety, form and origins of the same species give different reactions to the same ambient conditions and they are affected from the stress factors in different ways[38-39]. Therefore; it is possible for the sub-species, variety, form and origins of the same species to give different reactions under different ambient conditions regarding the indoor plants. For this reason; this issue should be taken into consideration and examined in the usage of the plants for the purpose of increasing the indoor air quality.

In addition; it is known that the ambient conditions significantly affect the photosynthesis speed of the plants and therefore, their impact on CO_2 amount. So; the inclusion of the factors such as light, plant dimensions, number of leaves etc. except for temperature is important in terms of determining which plant is more efficient depending on the ambient conditions in the studies to be conducted in the future. The studies in this issue should be varied and sustained**.**

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