Change of Chlorophyll Amount in Some Landscape Plants

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Change of Chlorophyll Amount in Some Landscape Plants

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Abstract

Pigments provide coloring in plants and the most important pigment among these is chlorophyll. Chlorophyll absorbs light energy and transforms it into chemical energy. Thus, it enables photosynthesis which provides oxygen and nutrients needed by all living things. In addition, chlorophyll is also the pigment that gives the plants their green color. The change of chlorophyll amount in plants affects coloring. Color is very important for landscape architecture studies. The objective of this study is to determine the relationship between color change and chlorophyll amount in various plants. To this end, the chlorophyll amount in various plants with natural and different colors along with the color changes that occur due to environmental factors have been examined and the relationship between color changes and chlorophyll amount was tried to be put forth.

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Introduction

In parallel with population increase, longing for nature and greenery increase continually in our cities that develop unhealthily and without any plan (Küçük and Gül, 2005). The longing of people living in urban areas towards nature, the lack of sufficient areas that will satisfy recreational demands forces humans who are part of the nature to arrange the space and environment in which they live; thereby the importance of open and green areas continues to increase.

Plants are the most important elements of open green areas. Plants have many aesthetic and functional tasks (Yeşil *et.al.,* 2006). Green areas make up the most dynamic portion of urban open-green areas with the ever developing-changing structure of their plant materials (Doygun and Ok, 2006). Plants are living things and they change color according to properties specific to their species and strain in addition to the effect of environmental factors along with changes that occur during their development periods.

Color is very important in landscape architecture planning. Different color types have different psychological and visual effects on people. Color is a factor that should be evaluated during the design process in landscape design. Because the color planes formed have direct effects on both the users and the usage of the space (Altınçekiç, 2000).

Pigments give color in plants and they are grouped as chlorophylls, carotenoids, phycobilins, flavonoids, betalains and betacyanins (Karakurt and Aslantaş, 2008). Chlorophyll is the most important one among these pigments and it enables photosynthesis to take place.

Photosynthesis is the production of organic compounds by light energy in chlorophyll containing living things. Along with chlorophyll, sun light is also necessary for photosynthesis to take place. Chlorophyll absorbs light energy and transforms it into chemical energy (Yakar and Bilge, 1987). Thus, it enables photosynthesis to take place during which oxygen and nutrients necessary for all living things in order to survive are produced. In addition, chlorophyll is the pigment that gives the plants their green color.

Leaves that take on colors other than green during their development period are very important as ornamental plants. Most are yellow, red or purple (Karakurt and Aslantaş, 2008). Chlorophyll, carotenoid and anthocyanins are responsible from the formation of these colors (Lancaster et.al., 1997). These plants contain enough chlorophyll for photosynthesis; however they also include high amounts of carotenoid and anthocyanins to sustain their characteristic colors. In addition, the color change in plants varies according to the decrease or increase in the chlorophyll amount (Karakurt and Aslantaş, 2008).

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Materials and Method

The study was carried out on landscape plants used for park, garden and road planting in Kastamonu Kuzeykent region. Measurements were carried out on at least 5 individuals from each species and on at least 10 leaves from each individual. The measurements were carried out for at least 10 repetitions on leaves with different color or color tones on the same individual or the regions with different color or color tones on the same leaf. Measurements apart from those carried out to determine chlorophyll concentration based on insolation were made during the day between 10:00-14:00 hours via Apogee CCM-200 brand chlorophyllmeter and results were obtained in Chlorophyll Concentration Index (cci) units.

Results

Initially, individuals with naturally different colors were compared in the study. In order to do this, plants in atropurpurea form with purple colored leaves were compared with completely green plants. To this end, measurements were carried out on *Prunus cerasifera*, *Berberis thunbergii* and *Acer pseudoplatanus* and these measurements were compared with green leafed individuals. The results of the measurements have been given in the Table 1.

Table 1. Chlorophyll concentration of dark or light green leaves on some ornamental plants

Species	Dark green leaves			Species	Light green leaves		
	Max.	Min.	Mean		Max.	Min.	Mean
Prunus cerasifera	24,7	13,1	**17,8**	*Ailanthus altissima*	46,8	29,5	**38,7**
Berberis thunbergii	35,9	17,2	**27,3**	*Rosa canina*	38,9	24,6	**30,3**
Acer pseudoplatanus	37,8	26,3	**30,7**	*Platanus orientalis*	19,8	14,2	**16,0**

When the table values are examined, it is observed that there is no distinct difference between the individuals with purple leaved and those with green leaves. This is an indication that in cases when the plant has same colored leaves, the chlorophyll content varies according to plant type instead of leaf color.

Vegetative growth is very important especially for ornamental plants used for landscaping purposes. Thanks to vegetative growth, the plant can be grown to preserve its DNA structure and hence its complete characteristic. However in heterovegetative growth, leaves of the stock and cleft individuals can be found on the same plant. Measurements have been carried out on Norway maples grown by grafting in order to determine the chlorophyll concentrations. Purple leaved individuals were grafted to saplings with green colored leaves, however shoots sprang out from the buds at the stock. Thus, green and purple leaves are found on the same individual. It was determined as a result of measurements carried out that the chlorophyll concentration varied between 12,0 and 12,7 cci in green leaves whereas it varied between 26,3 and 39,8 cci in purple leaves and that on average it was 32,3 cci. However, it should be noted that purple leaves are located at a position dominant to the crown canopy of the tree and that the green leaves are grown under shadow conditions.

Purple and green color leaves can be found on the same individual in *atropurpurea* form plants. This has especially been observed for *Berberis thunbergii*, *Acer pseudoplatanus*, *Mahonia aquifolium* and border *Forsythia intermedia* plants and measurements have been made. The results of these measurements have been given in the Table 2.

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Table 2. Chlorophyll concentration of green and non-green leaves

Species	Green Leaves			Purple Leaves		
	Max.	Min.	Mean	Max.	Min.	Mean
Berberis thunbergii	50,8	21,8	**34,7**	17,2	35,9	**27,3**
Acer pseudoplatanus	11,9	8,1	**10,1**	23,0	16,0	**18,4**
Mahonia aquifolium	30,2	18,6	**24,9**	10,5	7,0	**8,7**
Forsythia intermedia	60,7	20,4	**35,8**	5,9	3,7	**4,9**

It can be observed when the table values are examined that apart from *Acer pseudoplatanus* individuals, green colored leaves had a higher chlorophyll concentration on average. However, when the values of *Berberis thunbergii* are examined, it is observed that the minimum concentration amount in green colored leaves is 21,8 cci whereas the highest concentration amount for purple colored leaves is 35,9 cci. In this case, it is not possible to state that there is a relationship between leaf color in *Berberis thunbergii* and *Acer pseudoplatanus* and chlorophyll concentration. On the other hand, there are distinct differences between purple and green leaves in *Mahonia aquifolium* and border *Forsythia intermedia* plants. In fact, it can be stated that this difference is greater than 10 times for some leaves.

Green color can sometimes be observed together with different colors on these plants. The multicolored structure that is observed especially in *Euonymus japonica* has resulted in the extensive use of this plant in parks and gardens. Together with green color, purple can be seen on the same plant in *Berberis thunbergii*, orange in *Buxus sempervirens* and yellow in *Euonymus japonica*. The chlorophyll concentrations of sections where these colors are observed have been compared and the results have been given in the Table 3.

Table 3. Chlorophyll concentration of green and non-green leaves

Species	Green leaves			Non-green leaves			
	Max.	Min.	Mean	Color of leaf	Max.	Min.	Mean
Berberis thunbergii	29,7	11,1	**20,4**	purple	26,3	17,3	**21,7**
Buxus sempervirens	21,2	78,7	**52,7**	orange	6,8	3,9	**5,2**
Euonymus japonica	149,3	74,8	**101,2**	yellow	1,2	0,9	**1,1**

As can be seen in the Table 3, there is no distinct difference between the green colored section and the purple colored section in *Berberis thunbergii*, however there is a distinct difference in *Buxus sempervirens* and *Euonymus japonica* and it is especially observed in *Buxus sempervirens* and *Euonymus japonica* that the chlorophyll concentration measured on non-green sections is not sufficient for photosynthesis.

It has been observed that the new leaves that form during growth of plants is light green after which these colors darken, thus it can be stated that young leaves are light green and older leaves are dark green in color. Based on this information, measurements have been carried out on light and dark green leaves and the results have been given in the Table 4.

Table 4. Chlorophyll consantration of dark or ligth green leaves

Species	Dark gren leaves			Dark gren leaves		
	Max.	Min.	Mean	Max.	Min.	Mean
Ailanthus altissima	46,8	29,5	**38,7**	18,0	11,6	**15,3**
Acer pseudoplatanus	16,3	14,1	**15,0**	13,6	8,5	**11,5**
Rosa canina	38,9	24,6	**30,3**	12,5	4,4	**6,7**

As can be seen in the table, the chlorophyll content in light green leaves is smaller than that of dark green ones. This indicates that the chlorophyll amount is low in young leaves and that it increases as the leaf grows older. Measurements carried out on rose individuals with purple young leaves have yielded similar results. Whereas the chlorophyll concentration in newly formed leaves was 10,7 cci, this ratio in

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older leaves was determined on average as 34,7 cci. This verifies the fact that chlorophyll concentration is low in newly formed leaves and that the chlorophyll concentration increases as the leaves age.
Leaves first turn red or yellow and then either start falling or drying when they complete their biological lives. Measurements have been carried out on yellowing leaves of *Platanus orientalis, Acer pseudoplatanus* and *Ailanthus altissima* in order to determine its relationship with chlorophyll; chlorophyll concentrations of green, yellowing or completely yellow leaves were determined and listed in the Table 5.

Table 5. Chlorophyll consantration of different color leaves

Species	Green Leaf			Start falling			Falling Leaf		
	Max.	Min.	Mean	Max.	Min.	Mean	Max.	Min.	Mean
Platanus orientalis	20,1	15,1	**17,9**	7,4	5,3	**6,2**	1,3	1,0	**1,1**
Acer pseudoplatanus	20,4	11,8	**15,0**	6,2	4,4	**5,5**	1,5	1,2	**1,3**
Ailanthus altissima	36,5	23,6	**29,3**	16,4	6,5	**10,6**	4,9	1,3	**3,2**

When the table values are examined, it is observed that the chlorophyll concentration of green leaves is quite different than those of leaves that have started to turn yellow and those that have already turned yellow. This can be interpreted as a gradual decrease in the chlorophyll amounts of leaves that complete their biological lives and that finally the chlorophyll in the leaf is completely finished.
Trials were carried out to determine how the chlorophyll concentration varies in drying of plants due to non-natural causes (water shortage, poisoning etc.) by not giving water to the selected plants and drying them during their vegetation periods after which it was observed that chlorophyll amount decreased in parallel to the course of drying. The results obtained for leaves that naturally change color completely were similar to those of leaves that dry naturally.
Plants may sometimes become separated from the main stem during normal activities. This is especially applied on ornamental plants, the plants are reaped for sales purposes or leaves are separated from the main stem during pruning. In such cases, three leaves were removed from *Prunus laurocerasus*, *Forsythia intermedia*, *Cydonia Oblonga*, *Acer pseudoplatanus*, *Rosa canina*, *Mahonia aquifolium* and *Euonymus japonica*; the measured sections were marked and new measurements were made on the marked spots at the end of the 3rd day. The results of the measurements have been given in the Table 6.

Table 6. Change to Chlorophyll concentration of separated leaves

Species	1. Leaf		2. Leaf		3. Leaf	
	First day	3rd day	First day	3rd day	First day	3rd day
Euonymus japonica	27,40	14,30	27,50	22,10	16,90	11,10
Forsythia intermedia	11,20	54,30	19,50	55,10	8,10	54,70
Cydonia Oblonga	10,40	8,60	18,20	10,00	21,30	10,60
Acer pseudoplatanus	19,50	25,20	13,60	18,70	17,10	35,80
Rosa canina	11,20	13,60	11,90	23,50	13,30	7,10
Mahonia aquifolium	41,50	48,30	44,70	25,70	43,00	45,70
Prunus laurocerasus	66,70	113,30	86,20	103,40	102,10	116,10

When the table results are examined, it is observed that chlorophyll concentration generally increases and decreases in some leaves. It has been observed that leaves generally darken during drying and that some leaves wane and start losing their green color. This can be interpreted in leaves that dry and preserve their color as an increase in chlorophyll concentration per unit area in relation with the loss of water content in the leaf and in leaves that become discolored as the breaking up of chlorophyll.

Discussion

The chlorophyll amount in the laves change due to many factors such as plant type, shape of the leaf along with environmental factors (Gond et.al., 2012; Şevik et al., 2012, Şevik et al., 2013; Kopsell et.al., 2005). Studies carried out show that the chlorophyll content in plants is related with magnesium (Çelebi vet.al., 2011), iron (Güneş et.al., 1997), humic acid (Güneş et.al., 1997), nitrogen (Tunalı et.al., 2012) mercury, copper, cadmium and copper (Zengin, 2007). It is stated that newly formed leaves do not have sufficient chlorophyll, hence these leaves have light green color and that their colors darken as the chlorophyll amount increases with aging (Şevik et al., 2013). In addition, there are also studies putting forth the relationship between chlorophyll amount in leaves with the amount of light (Johnston and Onwueme, 1998; Şevik et al., 2012; Dai et al., 2009; Khan et al., 2000). It is stated that the chloroplasts of plants grown under extensive light conditions are small in number but large and that their chlorophyll contents are high (Kurtar, 2012).

Chlorophyll content varies according genetic structure as well in addition to plant type, amount of light and nutrition of the plant (Taner and Sade, 2005). Thus, chlorophyll amount can vary between species as well as among the same specie (Criado et al.. 2007; Canova et al., 2008). Besides, the leaves of polyploidy plants are green because their chlorophyll amount is high and the photosynthesis potential of these plants is greater in comparison with diploids (Tepe et.al., 2002).

In addition to these factors, chlorophyll amount and thus color varies according to drought stress (Kulaç, 2010; Aguero, 2008), salt stress (Yılmaz et.al., 2011; Acar et.al., 2011), air pollution (Elkoca, 2003) metals such as Zn, Fe, Cd, Ni (Van Assche and Clijsters, 1990; Sheoran et al., 1990; Zengin and Munzuroğlu, 2005) et.al. in addition to time during vegetation period (Zavoruev and Zavorueva, 2002). Chlorophyll amount is an indicator to determine the cold tolerance in plants (Perks et al., 2004). Demirel et.al., (2010) state that chlorophyll readings may be used to determine water stress during flowering period and the start of the fruit development period in watermelon plants. Knudson (1977) indicates that ozone damage on bean leaves may be measured accurately and practically by chlorophyll determination. The determination of chlorophyll which can be carried out practically in a short amount of time can be used in many applications.

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