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DETERMINATION OF AUTUMN LEAF COLOR CHANGES IN THE MEDITERRANEAN REGION AND BLACK SEA REGION: *PLATANUS ORIENTALIS L.* AND *ACER NEGUNDO L.*

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ABSTRACT

Plants have both functional and aesthetic roles in landscape design. The aesthetic properties of plants include color. Color has visual and psychological effects on human beings. The effect of color varies depending on different growth periods of foliation, florescence, fruit bearing, and falling times. Color changes of deciduous plants in autumn, have a significant place in planting design. In the study, the autumn color change of *Platanus orientalis* L. (oriental plane) and *Acer negundo* L. (ashleaf maple) was monitored under different climatic conditions in the province of Hatay, located in the Mediterranean Region and in the province of Kastamonu, located in the Black Sea Region. It was suggested in the results of the examination performed that for both plant types, yellow-green and red-brown, color tones, and brightness values were different from each other. Color change in leaves may vary for reasons including the position of plants, their habitats, and climatic properties.

Key words: Hatay, Kastamonu, Autumn color change, *Platanus orientalis L.,* Acer *negundo L.*

INTRODUCTION

Color takes important part at human life in architecture (Ferring, 2013; Serra *et al*., 2015), textile industry (Hsu *et al*., 2015), education (Al-Ayash, 2015) and landscaping (Stoecklein, 2009). Color has meaningful function in all of these parts. For instance, a different colored-building may be used as a determinative in large areas (Ferring, 2013). Landscape architecture is the art of planning, designing, protecting, and repairing natural and human made environments (Karaca and Kuşvuran, 2012). Therefore, it usually uses nature and/or products of nature as a material. The most important element in the art of landscape architecture in urban and rural areas is plant material (trees, shrubs, lawn, etc.) (Laurie, 1986; Özer *et al*., 2009; Stoecklein, 2009; Silva *et al*., 2012). The opinion that a plant material has a positive effect on the psychology of human beings who are externalized in urban places, and live under stress, has been widely accepted (Kaufman and Lohr, 2004; Özer, 2005; Erduran and Kabaş; 2010). It is known that human beings benefit from nature and its elements by connecting with them actively or passively by watching flowers in the park area or looking at the trees through a window. Even knowing that these areas exist around us provides psychological benefits (Kelkit, 2002; Özgüner, 2004; Ulrich and Parson; 1992).

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In landscape architecture, plants are used for functional and aesthetic purposes (Aslanboğa, 1997, Yılmaz and Irmak, 2004). Properties of plants such as shading, biological repair, erosion control, and creating windscreen and noise screen are taken into consideration in functional uses of plants, as well as for aesthetic purposes, such as size, color, texture, form, light, blossom, and seasonal color changes (Aslanboğa, 1997; Stoecklein, 2009). The color property of a plant is effective in taking interest to the desired point or area (Hansen, 2010; Elliot and Maier, 2012). The color effect may provide, through various organs of plants (bark color, shoot tip, leaf, flower, fruit), including combined usage with other colors may increase the effectiveness of the color. Leaf color contributes to the effectiveness of plant color for an entire year or during a certain season (Hansen 2010). Color may be defined as the feeling evoked by light through eyesight, depending on wavelength (Uzun 1999). When light, which is an electromagnetic wave, encounters a substance, the reflected part is perceived as color. The human eye perceives wavelengths of approximately 400-500 nm as blue, wavelengths of approximately 500-600 nm as green, and wavelengths of approximately 600- 700 nm as red. All colors in nature are obtained through the use of these three wavelengths in different intensities (Selçuk, 2008). Pigments of objects we see around us cause different color tones by absorbing rays at certain wavelengths, and reflecting some of them (Robinson, 2004; Karakurt and Aslantaş, 2008).
Photosynthetic pigments which play a basic role in the photosynthesis mechanism in plants, including chlorophyll a,

chlorophyll b, and carotenoids and pigments of the anthocyanin group with the antioxidant character play a role in plant coloration due to the rays they reflect (Karakurt and Aslantaş, 2008). The purpose of this study is to reveal the autumn color change of leaves in the species of *Platanus orientalis* L. (oriental plane) and *Acer negundo* L. (ashleaf maple) growing in two different geographical regions of Turkey (the Mediterranean Region and the Black Sea Region). It is supposed that the study shall be a model for landscape design studies for both the provinces of Hatay and Kastamonu due to similar climatic conditions and shall guide future studies.

MATERIALS AND METHODS

Material

The research was performed in 2013 in September, October, and November in the provinces of Hatay and Kastamonu (Fig 1). Hatay, in the southernmost part of Turkey, is on 36° 15′ North Latitude and 36° 08′ East Longitude and has an altitude of 100 m. A typical Mediterranean climate prevails, in the city (Governor's Office of Hatay, 2014). Kastamonu, located to the north of Turkey in the West Black Sea Region, has an altitude of 791 m along the Karaçomak Stream, tributary of Gökırmak (Öztürk and Özdemir, 2003). The city, which is located in the Europe-Siberia (Auxin) zone with respect to plant geography, is in a position that transits from a maritime climate to a terrestrial climate, whereas, the city center is under the influence of a terrestrial climate (Akman, 1990). The city is located on 33^0 47′ East Longitude and 41^0 22′ North Latitude. Monthly climatic data for 2013 of the cities of Hatay and Kastamonu, located in different regions and climatic zones (average temperature, moisture, wind speed and total precipitation), are given in Fig 2. Two species (*Platanus orientalis* L. and *Acer negundo* L.) were selected as plant materials used intensively in open green areas of both cities to determine the effectiveness of autumn leaf color.

Fig. 1. Location of research area

A CR-300 (Minolta) color measurement device was used for determining leaf color values of plants according to C.I.E (Commission Internationale de l'Eclairage) standards. Accordingly, L* indicates brightness (0= black, 100= white) value, a* indicates color change from green to red (+ a red, - a green), and b* indicates color change from yellow to blue (+ b yellow, - b blue). Furthermore, color intensity (chroma) was revealed with C* value (gets lighter and brighter while it gets higher); color tone was revealed with h^0 (hue) value (0^0-360^0: red, 90^0: yellow; 180^0: green, 270^0: blue).

Measurements were performed in weekly periods during September, October, and November. Three plants with similar ages were selected from the same area. Each had twenty-four measurement values taken from two different points of twelve leaves provided from all four sides of the plants, representing one week. Assessments were performed on the basis of weekly data obtained and suggestions related to the issue were made.

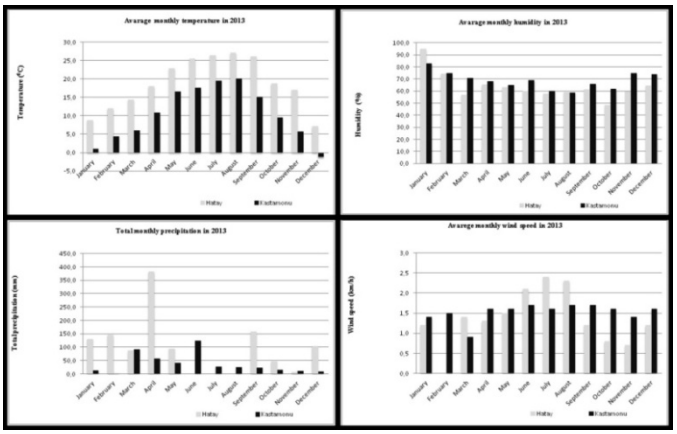

Fig. 2. The average monthly temperature, moisture, wind speed and total precipitation data of the provinces of Hatay and Kastamonu for 2013 (Kastamonu and Hatay Provincial Directorate of Meteorology 2013)

RESULTS

The leaf color change data of *P. orientalis* L. in autumn under conditions of Hatay and Kastamonu are given in Table 1; positions of a* and b* values obtained in the color space are given in Fig 3. The leaf color brightness value of the species, according to the data obtained, reached up to the highest value in November (Hatay: 53.85; Kastamonu: 46.41) under conditions of both cities. In Hatay, the leaves color were intensely green in September and October, yellow and brown in November. Under Kastamonu conditions, leaves were yellow-green color in September and October and dominance of a reddish brown color started in November. The decrease of chroma results increasing leaf darkness. Accordingly, under the conditions of both cities, the darkest leaf color was determined in September.

Table 1. Autumn color change of *P. orientalis* L. in autumn, under the conditions of Hatay and Kastamonu

Period	Hatay					Kastamonu				
	L*	a*	b*	C*	h^0	L*	a*	b*	C*	h^0
September	43.55	-13.00	23.69	27.12	119.03	40.96	-6.85	17.88	18.66	111.65
October	45.12	-13.73	29.29	32.86	116.32	42.07	-5.63	20.15	21.08	112.39
November	53.85	-11.34	35.39	38.29	126.11	46.41	2.5	25.59	26.57	183.96

Method

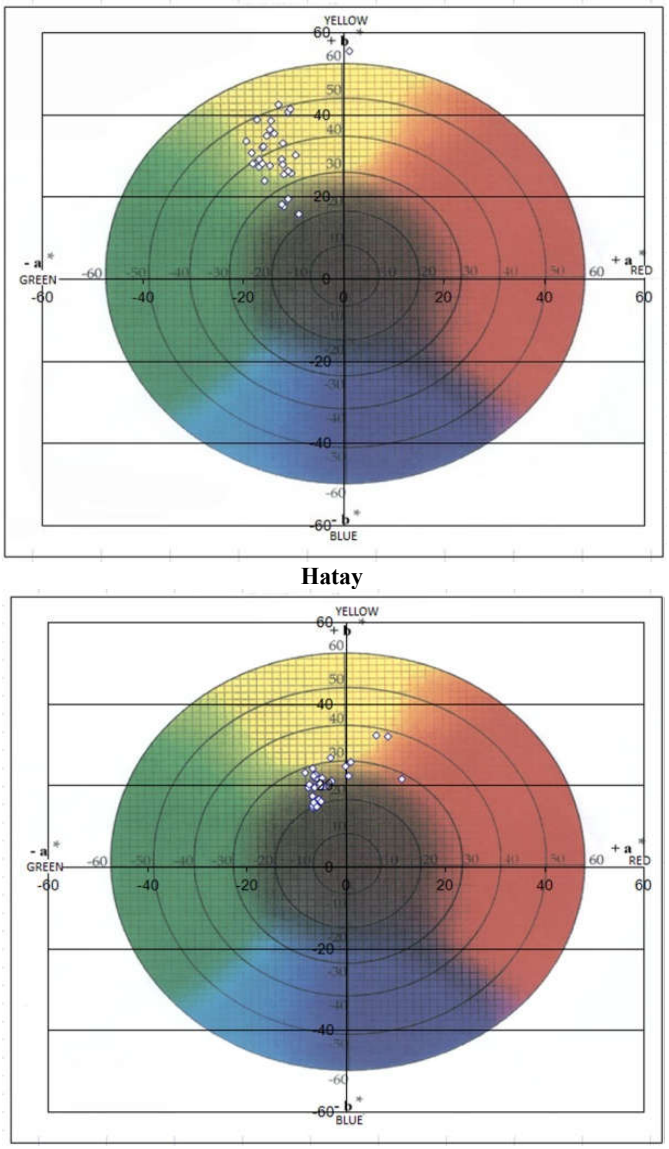

Fig. 3. Positions of autumn a* and b* values of P. orientalis L. in color space

The leaf color change data of the *A. negundo* L. in autumn under the conditions of Hatay and Kastamonu are given in Table 2; positions of a* and b* values obtained in the color space are given in Fig 4. The leaf color brightness value of the species, according to the data obtained, reached up to the highest value in November (Hatay: 55.14; Kastamonu: 60.35). *A. negundo* L. leaves have the darkest color tone in September under the conditions of Hatay and were green in September, yellow-green in October, and a yellow-brown color in November. Under the conditions of Kastamonu, leaves have the darkest color tone in November; and the leaves color were yellow-green in September and October and a reddish brown in November.

DISCUSSION AND CONCLUSION

Plant material, a significant design element within the occupational discipline of landscape architecture is used in areas from building scale to city scale. Plants are preferred due to their functional properties, including improvement of environment quality, shading, and determining direction in addition to aesthetical properties including form, color (leaf, flower, fruit, and bark), size, texture, form and other.

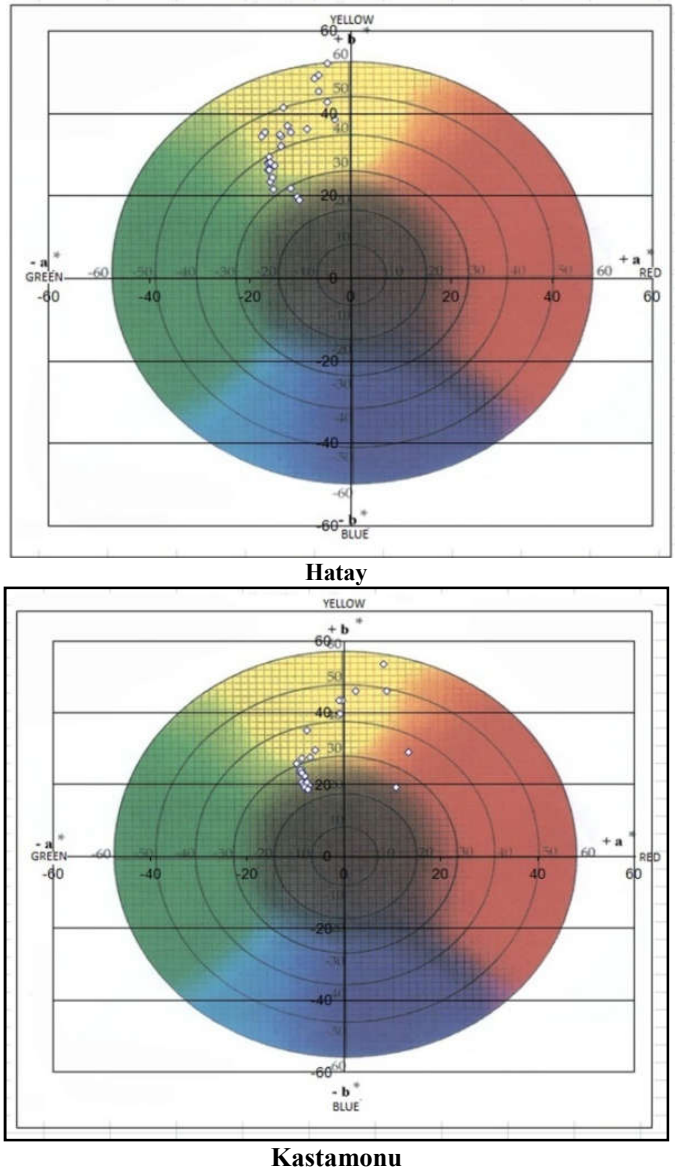

Fig. 4. Positions of autumn a* and b* values of A. negundo L. in color space

However, color is the most significant element of plant design (Yıldızcı, 1998). The autumn color change has always been an element that attracts the attention of human beings in deciduous plants (Archetti, 2000). For this reason, they were used in landscape design in order to provide emphasis and create focus point (Seçkin *et al*., 2011). In the study, leaf color change in autumn in different climatic zones performed in Hatay and Kastamonu of *Platanus orientalis* L. and *Acer negundo* L. species were determined. Accordingly, the following detections were made as a consequence of the study.

* Leaf color of *P. orientalis* L. is intensely green in September and October, and is yellow and brown in November under the conditions of Hatay. Prevalence of yellow-green in September and October and a reddish brown in November was detected under the conditions of Kastamonu.
* It was determined that the leaf color had a darker tone for the *P. orientalis* L. during autumn under the conditions of

Kastamonu compared to Hatay and the brightness value was higher in the Hatay conditions than the conditions of Kastamonu.

* The leaf color of the *A. negundo* L. was detected as being green in September, yellow-green in October, and yellow-brown in November under the conditions of Hatay. Under the conditions of Kastamonu, the leaf color turned to yellow-brown in September and October and reddish brown in November.
* The darkest leaf color tone of *A. negundo* L. was determined in September and November in Kastamonu, and under the conditions of Hatay in October. The brightness value was detected to be higher under the conditions of the city of Kastamonu in October and November.

Differences in colors tones emerging in both regions suggest regional differences as well. Colors change evidently when the region or the position changes. And the differences in starting and ending time of vegetation periods affect this as well. This is due to the vegetation period being shorter, particularly in the Black Sea Region compared to the Mediterranean Region when leaves begin to change color and become falling earlier. When climatic values of both cities are examined, it is observed that they have different properties with respect to rain, temperature, and wind; also similar properties with respect to humidity. This suggests that temperature and rain values may have higher effect on leaf color differences. Altitude difference may be the other indicator. Ecologic properties including soil properties were not examined within the scope of the study.

Kuş (2013) carried out in his study that color effectiveness of *A. negundo* was higher between September and December, that color effectiveness of *P. orientalis* was higher in November and December. So that these results should be considered in the designs to be made. The fact that similar results were obtained for the province of Hatay, located again in the Mediterranean Region, increases the correctness of the study. However, there is no study for Kastamonu and its vicinity and for this reason it is a model only for the region.
A. negundo L. and *P. orientalis* L. species have properties which include creating emphasis and focus points in open green areas through autumn color being used continuously in certain intervals, and contributing to revealing design principles including repetition and similarity (Kuş, 2013). These species create a relaxing effect with their green leaf color after foliation in spring, whereas they create positive, active effects in autumn creating liveliness and attractiveness with the leaf colors they show before leaf fall. Color changes have a positive psychological effect on human beings by reminding natural areas.

Both species, which are the subject matter of the study, are large sized trees and they are species which prefer using at open green areas and road afforestation in Mediterranean and Black Sea Regions with their aesthetic and functional properties. They are accepted to be among plant materials that could be included in landscape design in many different regions due to their general appearance in autumn, leaf colors, and making to be feel seasonal changes, as well as having a suitable growth environment in both northern and southern regions. Data on plant design obtained through the study reveals color differences under the conditions of the Mediterranean and Black Sea Regions on the basis of two species. The study shall be a model for other decorative plants used in landscape design.

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