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Research Article

Monitoring Autumn Color Changes of *Berberis thunbergii atropurpurea* D.C. and *Prunus laurocerasus* L. In Different Geographic Regions

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Abstract: The color of plant which is the most significant material of landscape design has visual and psychological effects on human beings. Color effect in plants varies in different periods of growth depending on foliation, florescence, fruit bearing and falling times. Variance of color in plants is an effective factor in the perception of places as well, according to species and regional differences, which increase the significance of the subject. In the study, the autumn leaf colors of *Berberis thunbergii atropurpurea*, one of the exotic species and *Prunus laurocerasus*, a wild species, were observed in order to reveal the effect of regional differences on leaf colors. Both of these plants are frequently found in green areas in the province of Hatay in the Mediterranean Region and the province of Kastamonu in Black Sea Region. As a result of the study, it was found that autumn leaf colors of both species were darker in Kastamonu. However, the color in leaves varies on a province basis. Accordingly, green and maroon colors are intense in the leaves of *B. thunbergii atropurpurea* under Hatay conditions and red and maroon colors are intense under Kastamonu conditions. The leaves of *P. laurocerasus* were detected as a yellowish green in Hatay and as a dark green in Kastamonu.
Keywords: Plant Design, Leaf Color, *Berberis thunbergii atropurpurea* DC, *Prunus laurocerasus* L.

INTRODUCTION

It is known that approximately more than half of the world's population lives in cities and this increases the significance of outdoor green areas [1,2,3]. In addition to being one of the most significant elements of urban life quality, urban green areas are considered as areas that contribute to ecologic, economic, social, health related subjects [4], and scientific studies [5,6,7]. Furthermore, outdoor green areas provide significant benefits, including the improvement of urban climate, protection of biodiversity, the creation of a living space for wild life [5,6,8], and repairing the ecosystem [4].

Plants are the most significant material of green areas and have many benefits, including increasing the feeling of belonging [9], highlighted through the composition they form with their surroundings [10], and supporting the social and biophysical development [11,12]. Subjects related to identification and distributions of plant species are studied by plant systematic experts, but visual experiment studies of those species are not very frequent. However, landscape architecture studies prefer to focus on aesthetic and functional qualifications of plants. Color, which is the most significant aesthetic characteristic, is a parameter, which is difficult to define and may change intuitionally[13] (*Grose*, 2012). Color varies depending on the age of the plant, light receiving condition, leaf thickness, texture of the plant, and the substances covering its surface [13] as well as temperature, pigments, pH, metals, sugars, anthocyanins, and cell type [14]. Studies on color are generally conducted in the fields of biology [15], orcharding [16,17], horticulture [18] cut floristry [19,20] and ornamental plants in recent years, though the number of those studies is low [21,22].

It is discussed by scientists that color differences are related to the phenomenon of place. For instance, it is possible that the green in the forests of Australia and the green in the forests of the Black Sea Region have differences between them [13]. This suggests that colors differ depending on region and ecologic conditions. Within this scope, the autumn color changes of *Berberis thunbergii atropurpurea* DC. and *Prunus laurocerasus* L., frequently found in green areas located in the provinces of Hatay (Mediterranean Region) and Kastamonu (Black Sea Region), have different geographical characteristics and different ecologic conditions, as monitored in the study. It is thought that the study shall be a model for landscape designs to be conducted and will consider the color principle in similar climates, for example, the cities of

Hatay and Kastamonu. In addition, it shall guide other conducted studies with the same subject.

MATERIALS AND METHODS

The research was conducted in September, October, and November of 2013, in the provinces of Hatay and Kastamonu (Fig. 1).

Hatay, in the south end of Turkey, is located on 36° 15´ north latitude, 36° 08´ east longitude. The altitude of the city, where a typical Mediterranean climate prevails, is 100 m [23]. Kastamonu is located in the north of Turkey, in the West Black Sea Region, on 410 22´ north latitude, 330 47´ east longitude. Its altitude is 791 m [24] and it is under the influence of a continental climate in a position transiting from a maritime climate to a continental climate [25]. Monthly climatic data of the provinces of Hatay and Kastamonu, located in different regions and climate zones for 2013 (average temperature, total rainfall, humidity and wind speed), are given in Fig. 2.

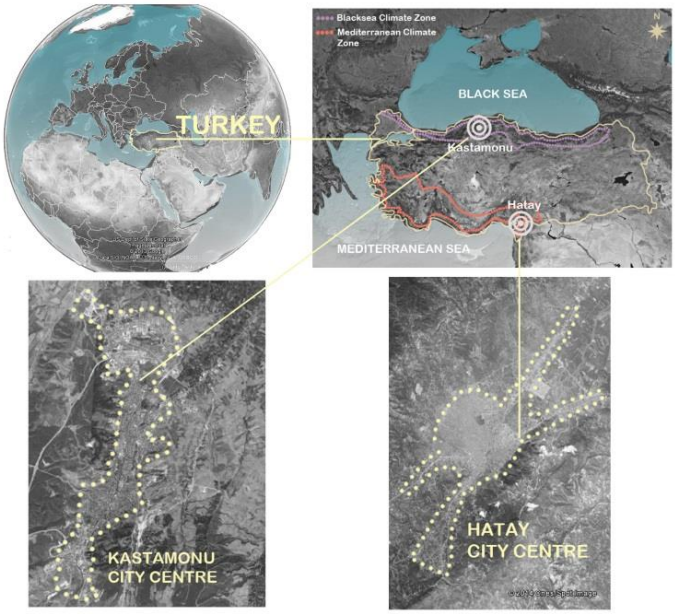
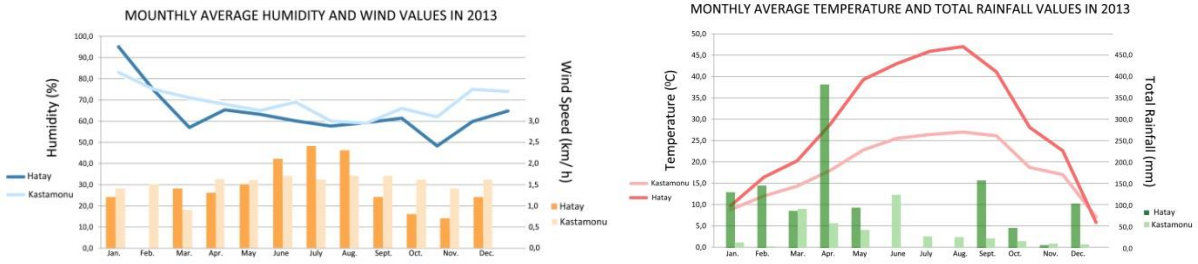


Fig-1: Position of research areas



a b

Fig-2: Average monthly humidity and wind speed (a) and temperature and total rainfall (b) data of the provinces of Hatay and Kastamonu for 2013 [26,27]

In the study, *B. thunbergii atropurpurea* DC with a tropical origin in the form of deciduous bush, a member of the *Berberidaceae* family and *P. laurocerasus* L., wild in both regions, in the form of an evergreen shrub, a member of *Rosaceae* family selected for use as plant materials in the study due to the fact that they are used intensely in green areas of both cities and due to their leaf color effectiveness.

A CR-300 (Minolta) color measurement device was used for the purpose of determining leaf color values of the plants; color values were determined according to C.I.E. (Commission Internationale de l'Eclairage) standards. Accordingly L* refers to brightness (0= black, 100= white) value, a* refers to color change from green to red (+ a red, - a green), and b* refers to color change from yellow to blue (+ b yellow, - b blue). Furthermore, the color intensity (chroma) C* value (the higher it gets the lighter and brighter it becomes) was revealed with a color tone h^0 (hue) angle value (0^0-360^0: red, 90^0: yellow; 180^0: green, 270^0: blue). Measurements were conducted in weekly periods during September, October, and November. Three plants with similar ages and located in the same area were selected. Twenty-four measurement values taken from two different points of

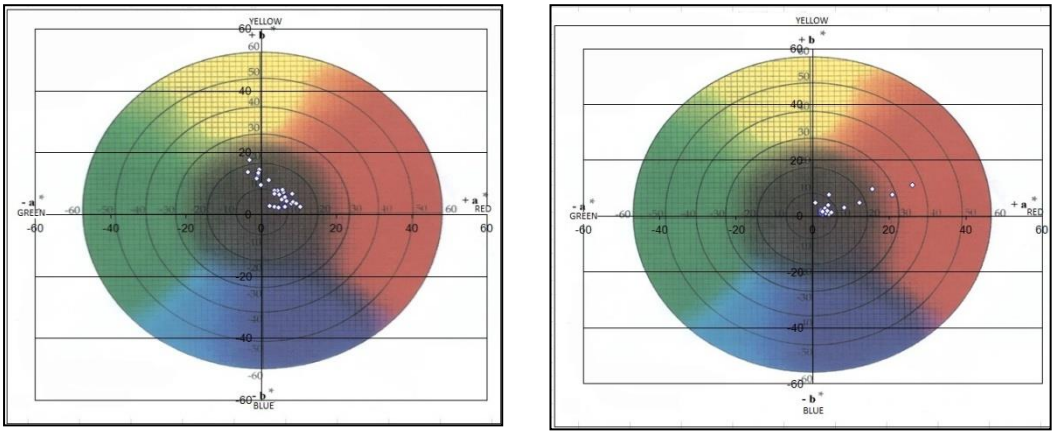
12 leaves from four sides of the plant, were represented each week. Arithmetic means of 4-week data were taken for each month and assessments and suggestions were made on the issue.

RESULTS AND DISCUSSION

Leaf color of *B. thunbergii atropurpurea* under the conditions of Hatay and Kastamonu was monitored in autumn. The data obtained is given in Table 1 and the position of a* and b* values obtained in the color space is given in Fig. 3. The leaves of the species generally contain the colors of green, red, and maroon. However, differences between colors on a provincial basis were detected in a quarterly observation period. Green and maroon were prevalent under the conditions of Hatay, and red and maroon were prevalent under the conditions of Kastamonu. The highest brightness value in the leaf was obtained in September under the conditions of Hatay (33.21), and in November under the conditions of Kastamonu (30.28). The darkest color tone was obtained in November in Hatay and in October in Kastamonu.

Table-1: Leaf color change of *B. thunbergii atropurpurea* under Hatay and Kastamonu conditions

Province	Period	L*	a*	b*	C*	h^0
Hatay	September	33.21	3.70	7.63	11.05	47.50
	October	28.75	3.58	8.10	11.35	49.95
	November	28.24	4.50	5.96	9.94	80.74
Kastamonu	September	28.69	2.44	3.11	4.66	205.33
	October	28.55	2.80	2.50	4.25	207.67
	November	30.28	12.00	5.88	13.59	208.10



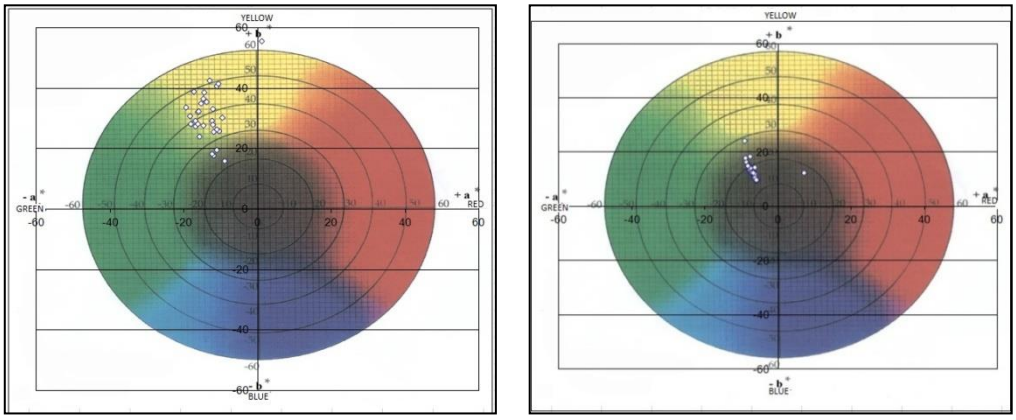
a. Hatay b. Kastamonu

Fig-3 Position of a* and b* values of the species of B. thunbergii atropurpurea cultivated in Hatay (a) and Kastamonu (b) in the color space

Leaf color of *P. laurocerasus* under Hatay and Kastamonu conditions was monitored in autumn and the data obtained is given in Table 2; the position of a* and b* values obtained in the color space is given in Fig. 4. The leaves of the species have a green color tone and the differences between colors on a provincial basis were detected in a quarterly observation period. When the differences in leaf color of the species of *P. laurocerasus* were compared, it was detected that a dark green color tone occurs under the conditions of Kastamonu and generally, a yellowish green color tone occurs under the conditions of Hatay. The highest brightness value in the leaf was obtained in November under the conditions of Hatay (41.10), and in September under the conditions of Kastamonu (36.58). The darkest color tone was obtained in September in Hatay and in November in Kastamonu.

Table-2. Leaf color change of *P. laurocerasus* under Hatay and Kastamonu conditions

Province	Period	L*	a*	b*	C*	h^0
Hatay	September	39.01	-12.60	18.42	22.43	125.32
	October	41.05	-9.56	25.41	28.55	118.80
	November	41.10	-8.83	23.36	26.31	124.05
Kastamonu	September	36.58	-7.82	15.11	17.09	119.07
	October	35.12	-7.02	12.53	14.39	119.76
	November	34.37	-6.49	12.12	13.79	119.20



a. Hatay b. Kastamonu

Fig-4. Position of a* and b* values of *P. laurocerasus* cultivated in Hatay (a) and Kastamonu (b) in the color space

"Color" effect is significant for providing certain qualities, both aesthetic and functional, in professional landscape architecture. Plants may be effective simultaneously with one, two, or more of their parts as leaves, flowers, fruits, and trunks on a seasonal basis. This is a factor that increases effectiveness in compositions where different plants are used together. The species of *B. thunbergii atropurpurea* and *P. laurocerasus* were selected as examples for the provinces of Kastamonu and Hatay and were used in groups of three and five, providing highlights of leaf colors in the area. The use of red-maroon colors in the plant of *B. thunbergii atropurpurea* in the form of a bush, particularly when used together with evergreen plants, creates a background. *P. laurocerasus*, in the form of a shrub, may create a highlight effect with its bright and thick textured green leaves in park areas, attracting attention in the four seasons, as it is evergreen.

B. thunbergii atropurpurea refers to the liveliness and dynamism in physical terms, and happiness, perseverance, and determination in emotional terms with its red and maroon leaf color. The leaf color symbolizes power and attracts attention [28]. It was found that the species used frequently in green areas as parks and roads in both cities have green and maroon leaf colors in autumn under the conditions of Hatay, and red and maroon leaf colors in autumn under the conditions of Kastamonu. In addition, leaf brightness values were found to be almost equal in both regions and there were not any significant differences. The leaf color in Kastamonu was darker than in Hatay.

P. laurocerasus species represents peace with its green leaves and evokes hope, renewal, and revitalization [28]. The leaf color of this species during autumn was detected as a yellowish green in Hatay and a dark green in Kastamonu. Leaf brightness values were detected to be higher in Hatay than they were in Kastamonu. In addition, leaf color was detected to be darker in Kastamonu than in Hatay.

CONCLUSIONS

The compositions arising in arrangements made using color characteristics of leaves, flowers, fruits, and trunks of plants emphasize human perception. For this reason, it is necessary to consider the colors of plants and their effects in the new designs created. It is recommended the species selected be used in the study together with other species designs, which would emphasize the principle of contrast for the purpose of highlighting and strengthening the design and visual attractiveness. Color effect in the plant occurs with leaves, flowers, fruits, trunks, seed colors, and the period when each organ is active varies. For this reason, the use of color effective trees, bushes, and multiyear herbaceous species in designs should be supported, considering seasonal changes.

Differences in the colors and tones arising in both regions reveal regional differences. When ecologic conditions change, colors significantly change too. The difference between start and end of vegetation periods affects this as well. Leaves begin to change color and drop earlier in the Black Sea Region, particularly due to the shorter vegetation period in the Region compared to that in the Mediterranean Region. When climatic values of both cities are examined, it is suggested that they have different characteristics, particularly with respect to rainfall and temperature conditions and those climatic characteristics may have an impact on the differences in leaf color. Furthermore, the altitudes of the two samples selected are different. Other effective factors, including soil, feed etc., were not assessed in the study.

Effectiveness of plant leaf color in designs was revealed through the conducted study. The data obtained shall be a model for landscape designs, considering the principle of color in climates similar to the climates of the provinces of Hatay and Kastamonu. At the same time, it is thought to guide other studies which will be conducted with regard to the same subject.

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