Comparison of Leaf Traits (SLA And LMA) on Different Populations of *Alcea apterocarpa*

Alcea apterocarpa (Fenzl) Boiss Farklı Populasyonlarında Yaprak Karakterlerinin (SLA ve LMA) Karşılaştırılması

Research Article

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ABSTRACT

In this study, we compared specific leaf area (SLA) and specific leaf mass (LMA) of *Alcea apterocarpa* (Fenzl) Boiss populations in different localities. SLA and LMA are important leaf parameters because they are related to leaf nutrients, leaf economy and gas exchanges with atmosphere. So many species adjust leaf parameters (i.e. SLA and LMA) across to environmental gradients. *A. apterocarpa* is a ruderal plant and has wide distribution area. Additionally it has got ethno botanic features for example use for medicine plant. We selected six individuals form three different localities for this study. Each locality has different density of the human populations. We collected green and senescence leaves from localities and calculated SLA and LMA values of these leaves. The results showed that there are very important differences between senescence and green leaf and between localities. Especially, SLA values of *A. apterocarpa* population in city center are found to be higher and LMA values are found to be lower than other populations.

Key Words
Alcea apterocarpa, Population, Specific leaf area, Specific leaf mass.

ÖZET

Bu çalışmada, farklı lokalitelerdeki *Alcea apterocarpa* (Fenzl) Boiss popülasyonlarının yaprak alanı ve spesifik yaprak ağırlığı değerlerini karşılaştırdık. SLA ve LMA önemli yaprak karakterleridir. Çünkü SLA ve LMA yaprak besinleri, yaprak ekonomisi ve atmosferle gaz alışverişlerinde ilişkilidir. Bu nedenle bir çok tür yaprak karakterlerini çevresel gradientlere karşı uyarlamaktadır. *A. apterocarpa* ruderal bir türdür ve geniş yayılış alanlarına sahiptir. Ayrıca etnobotanik özelliğe sahip olan örnek tedavi edici bitki özelliğine sahiptir. Çalışma için üç farklı lokalitede 6 birey seçtik. Her bir lokalite farklı nüfus yoğunluğuna sahip bölgelerden seçilmiştir. Lokalitelerden olgun ve senesens yapraklar toplanmış ve yaprakların SLA ve LMA değerleri hesaplanmıştır. Sonuçlar, senesens ile olgun yapraklar ve lokaliteler arasında önemli farklılıkların olduğunu göstermiştir. Özellikle, şehir merkezindeki *A. apterocarpa* populasyonunda SLA değeri diğer lokalitelere göre en yüksek iken, LMA değeri en düşük bulunmuştur.

Anahtar Kelimeler
Alcea apterocarpa, Popülasyon, Özgül yaprak alanı, Özgül yaprak kütlesi.

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INTRODUCTION

Leaf traits are very important in ecosystem dynamics, they response to environment and effect on plant functions. Specific leaf area (SLA) and specific leaf mass (LMA) of leaf traits are used in most studies [1]. Specific leaf area is related to net assimilation rate and plant relative growth rate [2,3]. Specific leaf mass related to environmental gradient stress for example higher LMA ratio was proved to be a primary adaptation to drought stress [4]. Each leaf traits are not yet clear explain to ecosystems dynamics at the global scale, so leaf traits are interpreted together [5,6].

The examination of leaf trait relationships of different ecosystems are therefore necessary. However, there is some studies [7] that leaf traits are evaluated with ecosystem properties at the community and the dominant species level. Community properties can influence ecosystem functions [8], it is important to determine, such as community level, dominant species and non-dominant species, have similar pattern in terms of leaf trait response to soil nutrient gradient and leaf trait effect on ecosystem properties [1]. A leaf nutrient economy spectrum runs from species with stingily limited leaf area but short duration return on investment, to species with high leaf mass per area (LMA) and long leaf lifespan. Higher nitrogen and phosphorus concentrations and faster gas exchange rate are associated with the lower LMA of the leaf nutrient economy. Herbs, grasses and deciduous trees tend towards the lower LMA final and evergreen shrubs and trees towards the higher LMA final, but there is wide overlap between growth forms [9-11].

In most of the studies on plant ecology and plant physiology, the mainly used leaf traits are specific leaf area (SLA) and leaf mass area (LMA) [12]. Specific leaf area is one of the most widely accepted key leaf characteristics used during the study of leaf traits, among other factors [13]. Specific leaf area can be used to estimate the reproductive strategy of a particular plant based upon light and moisture (humidity) levels [14]. Specific leaf area is the ratio of the dry weight of the plant leaf area and it is associated with the type of plant, ability to obtain water capacity, cover and the light intensity of the area where the plant is located [15]. In the interpretation of the plant's photosynthetic capacity and light requirements, SLA and LMA values could be seen as indicator leaf traits. LMA is expressed that is the ratio of plant leaf area of the plant dry weight. As LMA values may change depending on species, it may change between individuals of same species. Also depending on season and environmental conditions, LMA values may vary on the same species and also same leaf.

Alcea apterocarpa (Fenzl) Boiss is a perennial herbaceous plants and endemic for Turkey (Figure 1). Although *A. apterocarpa* is in hazard category of ''LC'', it has collected by the people for the aim of medical and as ornamental plant. In this study, it was compared specific leaf area (SLA) and leaf mass area (LMA) values statistically in different populations of *Alcea apterocarpa*, distributed in three different localities in Samsun. we aimed to investigate SLA and LMA values of *A. apterocarpa* were significantly changed or not in different populations. In addition, these values will be provide information us to understand the strategies of the plant and ecosystem dynamics.

MATERIALS AND METHODS

The study was conducted in three localities in Samsun province, taking into account human population and urbanization. The first locality, where the urbanization and human population is the most dense in city center namely Ilkadım. The second locality, where the human population and urbanization increasingly decrease, is Karasamsun. And the last locality where the absence of urbanization and is 20 km away from the city is forest area (in Campus of 19 Mayıs University) (Figure 2).

In the population of the selected localities, six different individuals have been identified. In the green and senescence period, leaf samples were collected from six individuals at between 2014 May and November. After cleaning the leaf samples collected from the field are pressed and dried. After drying, area of the leaf samples was measured by planimeter. Areas measured leaf samples are weighed and dry weight were determined, after drying in an oven at 65°C

Figure 1. Distribution area of *A. aptocarpa* in Turkey.

Figure 2. The location of the samples collected by localities.

until constant weight. SLA and LMA values are calculated using the following formula.

SLA= Total leaf area/Total dry leaf weight [1]

LMA = Total dry leaf weight/Total leaf area [2]

SPSS 20.0 software package was used for statistical analysis. For evaluation of the values of SLA and LMA, two-way analysis of variance (ANOVA) and Tukey-HSD tests were applied.

RESULTS

Both SLA and LMA values are statistically significant in terms of locality and season. When evaluated together with locality and season, although SLA value is statistically significant, LMA value is not (Table 1). According to the Tukey HSD test results, in terms of both SLA and LMA values, city centre and campus localities show statistically significant differences from each other. But there isn't statistically significant differences between campus and Karasamsun localities in terms of both LMA and SLA values (Table 2). It has been determined that *A. apterocarpa* populations taken from city center had the highest SLA and LMA (Table 3). SLA values are higher than senescence leaves in green leaves, especially in the city center. The highest SLA value is 3.157 dm^2/g in green leaves taken from city centre and the lowest SLA value is 0.724 dm^2/g in senescence leaves of Karasamsun locality (Figure 3). In contrast, LMA values are higher than green leaves in senescence leaves, especially

Table 1. Tests of between locality and seasonal effects in terms of SLA and LMA values.

Source	Dependent Variable	Type III Sum of Squares	df	Mean Square	F	Sig.
Locality	SLA	9.016	2	4.508	56.175	0.000**
	LMA	2.775	2	1.387	73.006	0.000**
Season	SLA	0.700	1	0.700	8.724	0.006**
	LMA	0.152	1	0.152	8.009	0.008**
Locality * Season	SLA	0.680	2	0.340	4.239	0.024*
	LMA	0.018	2	0.009	0.474	0.627

* p < 0.05, **p < 0.01

Table 2. The comparison of localities in terms of SLA and LMA values

Dependent Variable	Locality	Locality	Mean Difference	Std. Error	Sig.	95% Confidence Interval	
						Lower Bound	Upper Bound
SLA	Campus	City center	-1.0006	0.11565	0.000**	-1.2857	-0.7155
		Karasamsun	0.1131	0.11565	0.596	-0.1720	0.3982
	City center	City center	1.0006	0.11565	0.000**	0.7155	1.2857
		Karasamsun	1.1136	0.11565	0.000**	0.8285	1.3987
	Karasamsun	City center	-0.1131	0.11565	0.596	-0.3982	0.1720
		Centrum	-1.1136	0.11565	0.000**	-1.3987	-0.8285
LMA	Campus	City center	0.5092	0.05628	0.000**	0.3704	0.6479
		Karasamsun	-0.1358	0.05628	0.056	-0.2746	0.0029
	City center	City center	-0.5092	0.05628	0.000**	-0.6479	-0.3704
		Karasamsun	-0.6450	0.05628	0.000**	-0.7837	-0.5062
	Karasamsun	Campus	0.1358	0.05628	0.056	-0.0029	0.2746
		City center	0.6450	0.05628	0.000**	0.5062	0.7837

* p < 0.05, **p < 0.01

Table 3. Tukey HSD Test result for SLA and LMA values in terms of localities.

Tukey HSD (SLA)				Tukey HSD (LMA)			
Locality	N	SUBSET				SUBSET	
		1	2			1	2
Karasamsun	12	0.8497		City center	12	0.5486	
Campus	12	0.9628		Campus	12		1.0578
City center	12		1.9633	Karasamsun	12		1.1936
Sig.		0.596	1.000	Sig.		1.000	0.056

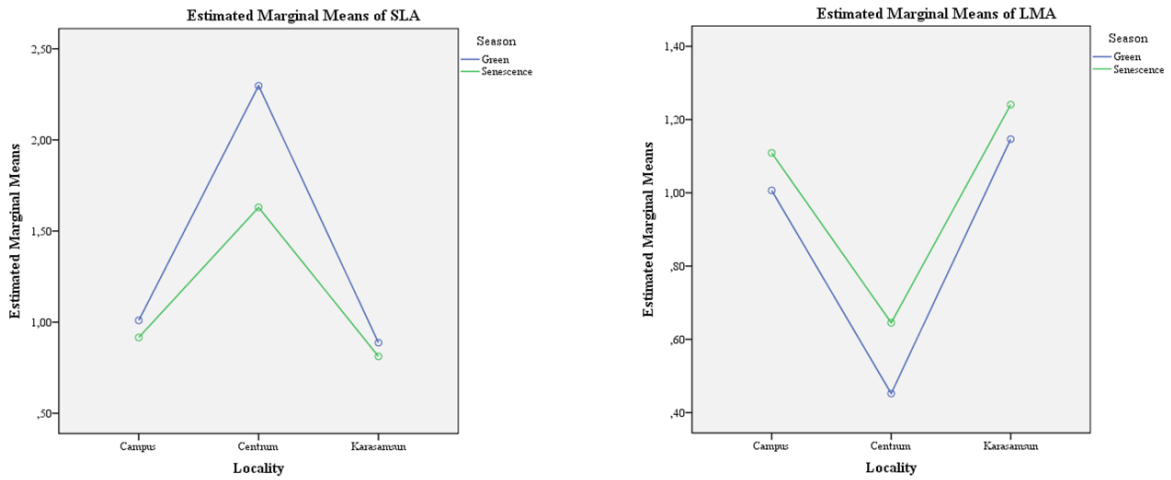

Figure 3. Seasonal and locality patterns of SLA and LMA values in *A. apterocarpa*.

in city centre. The highest LMA value is 1.379 g/dm^2 in senescence leaf of Karasamsun locality. The lowest LMA value is 0.316 g/dm^2 in green leaf of city center (Figure 3). Our results implied that SLA was found to be high in *A. apterocarpa* populations taken from city center. Because some significant ecological factors such as light density may be limited due to anthropogenic effects.

DISCUSSION

Specific leaf area (SLA) has a important role on growth and development of the plant and is also important in capturing the sun light [16]. Shipley & Almeida-Cortez (2003) stated that low light levels cause extreme increase in SLA [17]. The leaf traits that have the greatest plastic response could be more important for leaf functioning in different light environments [18]. In the present study, localities have got different light gradient and population densities and the city centre has low light level than the other localities due to urbanization so it has maximum SLA values in green and senescence leaves and their LMA values are minimum.

Markesteijn et al. (2007) stated that the correlation between SLA and leaf traits occur at different light levels, this might have led to a different detected plasticity among habitat types [19]. The plant communities are composed of semi-shrubs, forbs and grasses. In the present study, population type is perennial herb and characterized by low species richness. The mean values of leaf traits in these populations are similiar to those found by Wright et al. (2004) in the global dataset ($p>0.05$) [20].

LMA generally has got high values in arid habitats [21,22]. High LMA expresses high allocation of biomass per unit area and so allows for more photosynthetic tissue per unit area. While this is advantageous under hard conditions because of the trade-off with respiration [23]. In this study, we found maximum LMA values in campus and Karasamsun populations. Thus the strong relationships between plants are determined in these localities because of natural vegetation (ruderal vegetation).

When the leaves first occur, they have low weight and thin. Also the amount of water which they contain is more. Therefore, SLA value is high in the newly formed leaves, unlike the LMA values. In our study, we similarly found that SLA values are higher than senescence leaves in green leaves and LMA values are higher than green leaves in senescence leaves. During senescence, plants allocate nutrients in the leaves to resistant tissue before pouring their leaves. Through this mechanism, it is called resorption, leaf weight decreases, and in this period, leaf area increases parallely with increase amount of precipitation. So, the SLA value is expected to increase [24]. In our study, it has been shown that SLA values were not increased during senescence period. Drought

and water stress have varying effects on specific leaf area. In a variety of species, drought caused the decrease in specific leaf area [25-27]. Casper (2001) reported that under drought conditions, leaves were, on average, smaller than leaves on control plants [28]. This is a logical observation, as a decrease in surface area would mean that there would be fewer ways for water to be lost. Species with typically low specific leaf area values are geared for the conservation of acquired resources, due to their large dry matter content, high concentrations of cell walls and secondary metabolites, and high leaf and root longevity [29].

It has been shown that SLA reflects previously captured resources and indicates that species with high SLA exhibit high productivity [30,31]. Therefore, species with high SLA do better in resource-rich environments while species with low SLA do better in resource-poor environments where retention of captured resources is a higher priority. In our study SLA values are higher in centrum locality where soil fertility is high. This result shows that *A. apterocarpa* able to adapt the different conditions.

References

1. G. Wang, Leaf trait co-variation, respond and effect in a chronosequence. J. Veg. Sci., 18 (2007) 563.
2. P.B. Reich, M.B. Walters, D.S. Ellsworth, Leaf life-span in relation to leaf, plant and stand characteristics among diverse ecosystems. Ecol. Monogr., 62 (1992) 365.
3. J.H.C. Cornelissen, S. Lavorel, E. Garnier, S. Diaz, N. Buchmann, D.E. Gurvich, P.B. Reich, H. ter Steege, H.D. Morgan, M.G.A. van der Heijden, J.G. Pausas, H. Poorter, A handbook of protocols for standardized and easy measurement of plant functional traits worldwide. Aust. J. Bot., 51 (2003) 335.
4. I.J. Wright, P.B. Reich, M. Westoby, D.D. Ackerly, Z. Baruch, F. Bongers, J. Cavender-Bares, T. Chapin, J.H.C. Cornelissen, M. Diemer, J. Flexas, E. Garnier, P.K. Groom, J. Gulias, K. Hikosaka, B.B. Lamont, T. Lee, W. Lee, C. Lusk, J.J. Midgley, M.L. Navas, U. Niinemets, J. Oleksyn, N. Osada, H. Poorter, P. Poot, L. Prior, V.I. Pyankov, C. Roumet, S.C. Thomas, M.G. Tjoelker, E.J. Veneklaas, R. Villar, The worldwide leaf economics spectrum. Nature, 428 (2004) 821.
5. I.J. Wright, P.B. Reich, J.H.C. Cornelissen, D.S. Falster, E. Garnier, K. Hikosaka, B.B. Lamont, W. Lee, J. Oleksyn, N. Osada, H. Poorter, R. Villar, D.I. Warton, M. Westoby, Assessing the generality of global leaf trait relationships. New Phytol., 166 (2005) 485.
6. S. Lavorel, S. Díaz, J.H.C. Cornelissen, E. Garnier, S.P. Harrison, S. McIntyre, J.G. Pausas, N. Pérez-Harguindeguy, C. Roumet, C. Urcelay, Plant functional types; are we getting any closer to the Holy Grail? In: J. Canadell, L.F. Pitelka, D. Pataki, (eds) Terresterial ecosystems in an changing world. Springer - Verlag, Heidelbeg, DE. 2006.
7. E. Garnier, J. Cortez, G. Billes, M.L. Navas, C. Roumet, M. Debussche, G. Laurent, A. Blanchard, D. Aubry, A. Bellmann, C. Neill, J.P. Toussaint, Plant functional markers capture ecosystem properties during secondary succession. Ecology, 85 (2004) 2620.
8. J.P. Grime, Benefits of plat diversity to ecosystem: immediate, filter and founder effects. J. Ecol., 85 (1998) 902.
9. P.B. Reich, I.J. Wright, J. Cavender-Bares, J.M. Craine, J. Oleksyn, M. Westoby, M.B. Walters, The evolution of plant functional variation: traits, spectra, and strategies. IJPS, 164 (2003) 143.
10. P.A. Keddy, Competition. Springer-Verlag, Berlin, 2001.
11. M. Westoby, I.J. Wright, Land-plant ecology on the basis of functional traits. Trends Ecol. Evol., 21 (2006) 261.
12. A. Jullien, J.M. Allirand, A. Mathieu, B. Andrieu, B. Ney, Variations in leaf mass per area according to N nutrition, plant age, and leaf position reflect ontogenetic plasticity in winter oilseed rape (Brassica napus L.). Field Crop Res., 114 (2009) 188.
13. N.J.B. Kraft, R. Valencia, D.D. Ackerly, Functional traits and niche-based tree community assembly in an amazonian forest. Science, 322 (2008) 580.
14. R. Milla; P.B. Reich, Environmental and developmental controls on specific leaf area are little modified by leaf allometry. Func. Ecol., 22 (2008) 565.
15. A. Sellin, Morphological and stomatal responses of Norway spruce foliage to irradiance within a canopy depending on shoot age. Environ. Exp. Bot., 45 (2001) 115.
16. F. Valladares, E. Giandi, A. Saldana, Climbing plants in a temperate rainforest understory: searching for highlight or coping with deep shade. Ann. Bot., 108 (2011) 231.
17. B. Shipley, M.J. Lechowicz, The functional co-ordination of leaf morphology, nitrogen concentration, and gas exchange in 40 wetland species. Ecoscience, 7 (2000) 183.
18. L. Markesteijn, L. Poorter, F. Bongers, Light-dependent leaf trait variation in 43 tropical dry forest tree species. Amer. J. Bot., 94 (2007) 515.
19. T.J. Givnish, Comparative studies of leaf form: assessing the relative roles of selective pressures and phylogenetic constraints. New phytol. 106 (1987) 131.
20. S.A. Cunningham, B. Summerhayes, M. Westoby, Evolutionary divergences in leaf structure and chemistry, comparing rainfall and soil nutrient gradients. Ecol. Monogr., 69 (1999) 569.
21. J.R. Evans, H. Poorter, Photosynthetic acclimation of plants to growth irradiance: the relative importance of specific leaf area and nitrogen partitioning in maximizing carbon gain. Plant Cell Environ., 25 (2001) 754.

22. A. Sellin, Morphological and stomatal responses of Norway spruce foliage to irradiance within a canopy depending on shoot age. Environ. Exp. Bot., 45 (2001) 115.
23. B.B. Casper, I.N. Forseth, H. Kempenich, S. Seltzer, K. Xavier, Drought prolongs leaf life span in the herbaceous desert perennial Cryptantha flava. Funct. Ecol., 15 (2001) 740.
24. N. Marron, E. Dreyer, E. Boudouresque, D. Delay, J.M. Petit, F.M. Delmotte, F. Brignolas, Impact of successive drought and re-watering cycles on growth and specific leaf area of two Populus canadensis (Moench) clones,"Dorskamp"and "Luisa_Avanzo". Tree physiol., 23 (2003) 1225.
25. R.G. Laureano, Y.O. Lazo, J.C. Linares, A. Luque, F. Martínez, J.I. Seco, J. Merino, The cost of stress resistance: construction and maintenance costs of leaves and roots in two populations of Quercus ilex. Tree physiol., 28 (2008) 1721.
26. B.B. Casper, I.N. Forseth, H. Kempenich, S. Seltzer, K. Xavier.. Drought prolongs leaf life span in the herbaceous desert perennial Cryptantha flava. Func. Ecol., 15 (2001 740.
27. N. Marron, E. Dreyer, E. Boudouresque, D. Delay, J.M. Petit, F.M. Delmotte, F. Brignolas, Impact of successive drought and re-watering cycles on growth and specific leaf area of two Populus canadensis (Moench) clones,"Dorskamp"and "Luisa_Avanzo". Tree physiol., 23 (2003)1225.
28. H. Poorter, A. Van der Werf, Is inherent variation in RGR determined by LAR at low irradiance and by NAR at high irradiance? A review of herbaceous species. Inherent variation in plant growth. Physiological mechanisms and ecological consequences. Leiden, the Netherlands: Backhuys Publishers, 1998.
29. A. Van der Werf, R.M. Geerts, F.H. Jacobs, The importance of relative growth rate and associated traits for competition between species during vegetation succession. Inherent Variation in Plant Growth. Physiological Mechanisms and Ecological Consequences. Leiden, Netherlands, Backhuys Publishers, 1998.
30. P. Wilson, K. Thompson, J. Hodgson, Specific leaf area and leaf dry matter content as alternative predictors of plant strategies. New Phytol., 143 (1999) 155.
31. J. Liu, D. Zeng, D.K. Lee, Z. Fan, L. Zhong, Leaf traits and their interrelationship of 23 plant species in southeast of Keerqin Sandy Lands, China. Frontiers of Biology in China, 3 (2008) 332.