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Changes of plant nutrients K and Mg in several plants based on traffic density and organs

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Abstract: Among the mineral nutrients, potassium (K) and magnesium (Mg) are essential mineral nutrients for plants' growth, development, and many biochemical processes, such as photosynthesis. If K or Mg is not present in plants, they are adversely affected by this situation. The excess of K and Mg concentration in plant tissues results in plants' toxicity. This study aimed to determine the variations in K and Mg element concentrations in branches, leaves, and seeds of *Aesculus hippocastanum* L., *Prunus cerasifera* Ehrh., *Tilia platyphyllos* Scop., *Acer negundo* L., and *Ailanthus altissima* (Mill.) Swingle, which are frequently used in urban areas, especially in landscape studies, based on traffic density. As a result, the changes in the elements based on the traffic density in all organs and organs in all traffic densities were significant ($P<0.05$). The highest concentrations were often found in individuals grown in areas with heavy traffic. The study results revealed that the element concentrations could show significant differences between organs in the same species, and this difference varies significantly based on species.

Keywords: Magnesium, Nutrient, Plant, Potassium, Traffic density.

Öz: Mineral besinler arasında potasyum (K) ve magnezyum (Mg), bitkilerin büyümesi, gelişmesi ve fotosentez gibi birçok biyokimyasal süreç için gerekli mineral besinlerdir. Bitkilerde K veya Mg noksanlığından olumsuz etkilenirler. Bitki dokularındaki fazla K ve Mg konsantrasyonu, bitkilerde toksisiteye neden olur. Bu çalışmada kentsel alanlarda, özellikle peyzaj çalışmalarında sıklıkla kullanılmakta olan *Aesculus hippocastanum* L., *Prunus cerasifera* Ehrh., *Tilia platyphyllos* Scop., *Acer negundo* L., and *Ailanthus altissima* (Mill.) Swingle'ın dal, yaprak ve tohumlarındaki K ve Mg elementlerinin trafik yoğunluğuna göre konsantrasyonlarındaki değişimlerin belirlenmesi amaçlanmıştır. Sonuç olarak, elementlerin bütün organlarda trafik yoğunluğuna bağlı olarak, bütün trafik yoğunluklarında da organ bazında değişiminin istatistiki olarak anlamlı düzeyde olduğu belirlenmiştir ($P<0.05$). En yüksek konsantrasyonlar genellikle yoğun trafiğin olduğu bölgelerde yetişen bireylerde elde edilmiştir. Çalışma sonuçları element konsantrasyonlarının aynı türlerde organlar arasında önemli düzeyde farklılıklar gösterebildiğini ve bu farklılığın tür bazında da önemli ölçüde değiştiğini ortaya koymaktadır.

Anahtar Kelimeler: Magnezyum, Besin elementi, Bitki, Potasyum, Trafik yoğunluğu.

1. Introduction

Plants are the living groups that form the basis of all life on earth, and all life on earth is indirectly or directly based on plant species [1]. This dependence is that plants can produce food with the help of sunlight by performing photosynthesis. Thus, plants form the basis of the food pyramid. In addition, plants achieve many ecological, economic, and social roles [2, 3].

The ability of plants to perform these roles relies on their vigorous growth and development. The shared interaction of plant genetic structure [4-6] and environmental factors play a crucial role in plant development [7-9]. It is necessary to understand this mechanism to assure plants' ideal growth and development and shape this expansion according to the desired goals [10].

The most dominant environmental factors affecting plant growth are climatic [11-14] and edaphic situations [15-17]. Perhaps the most important of these factors is nutritional elements. Nutrients are the basic building blocks of plants and are present at different levels in different organs of plants after they are taken from the soil [10, 18], not only in their natural habitat [19] but also in their marginal lands [20]. Another factor affecting plant growth is environmental stress conditions [21-27]. Studies show that traffic can also become a source of stress for plants by affecting air quality [18]. The literature states that increased traffic density and industrial and other various anthropogenic activities accelerate the metal pollution in the world, especially in urban sites. Increased traffic density causes many environmental problems (air or smog pollution), which results in some health problems, such as heart disease and lung cancer, and increases the risk of respiratory infections. Therefore, the current study aimed to define the variations in the concentrations of potassium (K) and magnesium (Mg), which are essential nutrients for plants, in the organs of various plant species grown in areas with different traffic densities. K and Mg, which are among the nine essential macronutrients in plant nutrition, are crucial for plant development, and their deficiencies or toxicity cause various disease signs in plants and even plant destruction if not treated [28].

2. Material and Method

The present study was carried out on horse chestnut (*Aesculus hippocastanum* L.), ornamental plum (*Prunus cerasifera* Ehrh.), linden (*Tilia platyphyllos* Scop.), maple (*Acer negundo* L.), and tree of heaven (*Ailanthus altissima* Mill.) species that are often used in landscape studies. The samples were picked from the previous year's shoot, that is, from the 1-year-old part. As a seed sample, the seed part of the *Aesculus hippocastanum*, the fruit flesh part was used together with the shell for *Prunus cerasifera*, and the seeds with the stem and wings for other species were used. The samples were obtained towards the end of the growing season (late september) and were placed in labeled plastic bag and taken to the laboratory.

The collected samples were placed in laboratory conditions for 15 days until they became dry at room temperature and put in an oven at 45°C for two weeks. 6 ml of nitric acid (65% - HNO_3) and 2 ml of hydrogen peroxide (30% - H_2O_2) were added to the 0.5 g of the dried ground samples and placed in the microwave oven. The program of the microwave instrument was set to rise to 200 °C for 15 minutes and stay at 200°C for 15 minutes. After the samples were digested in that instrument, the solution samples were taken into flasks and filled up to 50 ml with ultrapure water, and then the K and Mg concentrations were determined with the ICP-OES (GBC Scientific Equipment Pty Ltd., Melbourne, Australia) instrument. In recent years, this method has been one of the most frequently used methods for determining plant elemental analysis [18, 29]. Analysis of variance was applied to the obtained data using the SPSS 22.0 statistical package software program, and homogeneous groups were found using the Duncan test for the factors that were found to have significant changes with at least a 95% confidence interval ($P<0.05$).

3. Result

The variation of K concentration, one of the macronutrients evaluated in the study, depending on the traffic density based on species and organs, and the statistical analysis results are given in Table 1.

As a result of the analysis of variance, the K element change was found to be significant ($P<0.001$) in terms of the traffic density in all organs and depending on the organs in all traffic densities. When the average values are evaluated, there is no linear change in the K concentration in the leaves based on the traffic density in general. However, the two highest values were found in *Tilia platyphyllos* leaves and seeds in areas with heavy traffic. Apart from this, it is seen that the highest values in many organs were obtained in areas with heavy traffic. As a species, the highest values were found in *Tilia platyphyllos* and the lowest values in the *Aesculus hippocastanum* tree. As an organ, the change is as follows: seed>leaf>branch in *Acer negundo* and seed>leaf>branch in *Ailanthus altissima* tree.

Table 1. The variation of K element concentration (ppm) by traffic density and species and organs

Species	Organ	Traffic density			
		None	Less	Heavy	F-value
Prunus cerasifera	Leaf	8998.50 Ai	16392.20 Bi	16902.27 Cj	9569.1***
	Seed	2773.83 Ab	24546.36 Cn	4364.83 Bd	291644.3***
	Branch	8443.46 Ch	6093.86 Be	3588.17 Ac	42155.9***
Aesculus hippocastanum	Leaf	3270.80 Cc	1435.96 Aa	3085.03 Bb	36377.4***
	Seed	5706.53 Be	2099.53 Ab	10199.47 Cg	97938.7***
	Branch	1759.10 Aa	3143.86 Cc	2633.80 Ba	19126.5***
Tilia platyphyllos	Leaf	7062.46 Ag	23740.06 Bl	39743.77 Cn	72049.3***
	Seed	7170.53 Ag	24103.60 Bm	40351.60 Co	15362.9***
	Branch	8309.56 Bh	9692.83 Cg	7659.10 Af	2192.8***
Acer negundo	Leaf	17698.53 Al	20600.03 Ck	18678.67 Bk	553.9***
	Seed	30746.43 Cm	28405.90 Bo	26065.40 Am	451.8***
	Branch	10599.10 Bj	5512.26 Ad	12916.73 Ci	17578.5***
Ailanthus altissima	Leaf	5528.80 Ad	14626.96 Ch	12457.70 Bh	37396.2***
	Seed	15810.56 Ak	17635.83 Bj	19532.60 Cl	1539.6***
	Branch	6557.03 Bf	6680.10 Cf	6034.27 Ae	467.5***
F-value	17960.8***	23903.1***	63002.1***		

Note: Different letters represent significant differences at alpha=*0.05*. Capital letters represent horizontal direction, whereas lower case letters represent vertical directions. *** = *P<0.001*.

The variation of Mg concentration, another macronutrient evaluated in this study, depends on the traffic density based on species and organs, and the statistical analysis results are given in Table 2.

The Mg concentration was significant in terms of the traffic density in all organs and on the organs in whole traffic densities ($P<0.05$). This change is significant only in *Ailanthus altissima* seeds at the 95% ($P<0.05$) confidence level based on the traffic density and at the 99.9% confidence interval for whole other factors.

When the variation of Mg concentration was evaluated, the highest concentrations were generally found in the species grown in heavy traffic areas. However, there was no significant changes between the organs of the species grown in areas with no traffic and less density ($P<0.05$). Apart from this, it can be said that the Mg concentration does not differ significantly based on species and organs.

Table 2. The variation of Mg element concentration (ppm) by traffic density, species and organs

Species	Organ	Traffic density			F-value
		None	Less	Heavy	
Prunus cerasifera	Leaf	5771.20 Cc	5761.90 Ac	5763.46 Bc	553.1***
	Seed	10724.13 Bi	8923.50 Af	21411.33 Cj	39379.7***
	Branch	9909.03 Af	10150.96 Bh	11514.23 Ch	2391.0***
Aesculus hippocastanum	Leaf	6628.60 Bd	6634.30 Cd	6620.10 Ad	957.4***
	Seed	4599.46 Ca	4274.76 Ba	3563.16 Aa	3264.5***
	Branch	8546.93 Be	6620.50 Ad	13237.13 Ci	637682.3***
Tilia platyphyllos	Leaf	5756.20 Ac	5762.70 Bc	11504.20 Ch	206263651***
	Seed	11498.46 Aj	11511.56 Bk	22980.76 Ck	54493641***
	Branch	11495.73 Cj	11450.36 Bj	9151.23 Ae	22005.2***
Acer negundo	Leaf	5768.80 Cc	5755.40 Ac	5756.56 Bc	561.3***
	Seed	5758.10 Ac	8628.26 Be	11498.43 Ch	2251691.9***
	Branch	11523.46 Bj	9127.73 Ag	11498.46 Bh	4249.6***
Ailanthus altissima	Leaf	10282.86 Ch	5139.90 Ab	10267.90 Bg	35268976.7***
	Seed	5140.70 Bb	5139.16 Ab	5138.40 Ab	9.05*
	Branch	9998.26 Ag	10301.03 Ci	10224.43 Bf	1571.1***
F-value		73981.6***	48182.6***	148104.4***	

Note: Different letters represent significant differences at alpha=*0.05*. Capital letters represent horizontal direction, whereas lower case letters represent vertical directions. * = $P<0.05$; *** = $P<0.001$.

4. Discussion and Conclusion

The changes of K and Mg elements evaluated in this study depending on organs in all traffic densities and all organs of all species based on traffic density were statistically significant. The elements in the study are essential for plant development, and K has critical importance in adaptation to several stress situations and plant-water relations [3,19,30]. Mg is located in plants' chlorophyll and traps sunlight, energy photons. Mg is the primary atom of chlorophyll and is crucial in the process of photosynthesis. Therefore, the concentration of chlorophyll is decreased, and photosynthesis is reduced, and as a result, its development is hindered under Mg deficiency [10].

As a result, it was determined that the element concentrations in the plants' organs changed significantly based on species and organs. Many studies have revealed that the concentrations of numerous elements vary significantly based on plant types [31-33]. The potential of heavy metal accumulation in plants grown in a similar habitat varies depending on plant type, plant habitus, plant organ structure, physio-chemical properties of metals, organ morphology, surface texture and size, surface area, exposure time to heavy metal, and the portion of particulate matter [34-36].

The element accumulation in plant species is closely associated with plant habitus and metabolism [37]. Therefore, it is stated that several factors such as the plant's stress severity [22-24], the genetic structure of the plant [38-40], hormone applications [41-44], cultural processes such as pruning, shading, and fertilization [20, 45-47] affect the heavy metals accumulation in plants [48].

As a result, the highest concentrations in two elements were found in the organs of plants grown in heavy traffic areas. The entrance of elements into the plant bodies can be primarily via leaves and roots. However, it is challenging to specify the primary source of the elements defined in the plants' bodies because the pathways of uptake in these two organs may work simultaneously [49, 50]. Therefore, air and soil composition also affect plant element concentrations [10]. In recent years, it has been determined that air pollution in urban areas has increased significantly in connection with industrial activities and traffic density [51-53]. Along with air pollution, it is stated that the heavy metals concentration, many of which also serve as nutrients for plants, increases significantly in this process [54]. This situation can significantly change the element content in the air and soil in the environment where the plants grow. Studies showed that particulate matter in the air is contaminated with various elements and that these particulate substances adhere to the organs and increase the element concentration in the organs [55, 56].

In conclusion, the element concentration change in organs of the plant is caused by a complicated mechanism depending on various factors' interaction, and that mechanism has not been entirely explained yet. For this reason, the further studies on this topic should be continued by diversifying and expanding, and the studies should be carried out in controlled environments as much as possible are recommended.

Competing Interest / Conflict of Interest

The authors declare that they no conflict of interest. The none of the authors have any competing interests in the manuscript.

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