Variation in P Resorption Effeciency and Proficiency in *Cornus mass* L. Leaves according to Leaf Location and Traffic-based Pollution

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Abstract

This study aimed to determine the variation in P resorption effeciency and proficiency in *Cornus mass* L. (cornelian cherry) leaves according to leaf location and traffic-based pollution. The study was carried out in Durağan, Sinop, which is famous with quality cornelian cherry fruits. Leaf samples were collected from two different *C. mass* orchards by considering leaf location and traffic-based pollution. The microwave method was applied for leaf sample dissolution and P concentrations were determined by ultra-violet spectrophotometric method as mg g^{-1} dry weight. Results showed that differences in P concentration according to leaf location were only significant in green leaves. A significant variation was found in P concentration only in away green leaves from fruit between polluted and unpolluted leaves. Except that of polluted away leaves from fruit, differences in P concentrations between green and senescent leaves were significant in other type of leaves. Both in polluted and unpolluted leaves, differences in PRE values between close leaves to fruit and away leaves from fruit were not significant. PRP didn't significantly vary according to any of the parameters. *C. mass* leaves efficienctly use P while their P resorption proficiency was low. It was determined that half of the P content in *C. mass* leaves was reabsorbed from senescent leaves.

Keywords —*Cornus mass*, phosphorus, resorption efficiency, resorption proficiency

Cornus mass L. Yapraklarında P Geri Emilim Verimliliği ve Yeterliliğinin Yaprak Yeri ve Trafik Kaynaklı Kirliliğe Bağlı Değişimi

Özet

Bu çalışmada, *Cornus mass* L. yapraklarında P geri emilim verimliliği ve yeterliliğinin yaprak yeri ve trafik kaynaklı kirliliğe bağlı olarak değişiminin belirlenmesi amaçlanmıştır. Çalışma, kaliteli kızılcık meyveleri ile ünlü olan Sinop, Durağan'da gerçekleştirilmiştir. Yaprak örnekleri yaprak yeri ve trafik kaynaklı kirlilik göz önünde bulundurulmak suretiyle iki farklı kızılcık bahçesinden toplanmıştır. Yaprak örnekleri mikrodalga yöntemi ile çözüldükten sonra P konsantrasyonları UV spektrofotometre ile mg g^{-1} kuru ağırlık cinsinden belirlenmiştir. Sonuçlar, fosfor konsantrasyonunda yaprak yerine bağlı olarak gözlenen farklılığın yalnızca yeşil yapraklarda önemli olduğunu göstermiştir. Kirlenmiş ve kirlenmemiş yapraklar arasında sadece meyveden uzak yapraklarda gözlenen P konsantrasyonundaki varyasyonun önemli olduğu belirlenmiştir. Kirlenmiş meyveden uzak yapraklar hariç, diğer tüm yaprak tiplerinde yeşil ve senesens yaprakların P konsantrasyonları arasındaki farklılık önemlidir. Hem

kirlenmiş hem de kirlenmemiş yapraklarda PRE'de meyveye yakın ve meyveye uzak yapraklar arasında gözlenen farklılık önemli değildir. PRP hiçbir parametreye bağlı olarak önemli bir değişim göstermemiştir. P geri emilim yeterlilikleri düşük olmasına karşın *C. mass* yapraklarında P verimli bir şekilde kullanılmıştır. Senesens *C. mass* yapraklarındaki fosforun yarısının geri emildiği belirlenmiştir.
Anahtar Kelimeler —*Cornus mass*, fosfor, geri emilim verimliliği, geri emilim yeterliliği

1 Introduction

Phosphorus (P) is one of the most limiting essential elements to plant growth in terrestrial ecosystems [1]. Since P is a component of nucleic acids, phospholipids, and ATP, it is vital to plant metabolism and reproduction [2]. Because of its importance for plant growth, plants should efficiently use P in order to not be overly dependent on the nutrient uptake from soil [1, 3]. Perennial plants absorb and transport nutrients from senescent leaves to durable organs and they can reuse nutrients that are contained within their leaves. This mechanism is called as resorption. By means of this process, plants also reduce nutrient loss due to leaf abscission. This process is important for both plant nutrient conservation and nutrient cycles. Reusing nutrients by resorption enables plants a selective advantage especially for crop plants. This process is important for plant growth and nutrient conservation. There are two measures of resorption that are resorption efficiency and proficiency. Resorption efficiency is determined as percentage amount of the nutrients withdrawn from the senescens leaves before abscission [4]. Resorption proficiency is the residual nutrient concentration in senescent leaves [5]. Resorption efficiency and proficiency are affected by several factors such as plant species and imposed ecological conditions [6, 7].

There are numerous resorption studies in the literature that focused on different aspects of resorption such as determining nutrient resorption of plant species [5, 6] and different growth forms, factors that are effective on resorption [7] and effect of resorption process on ecosystems [8]. However, it is supposed that there are several unknown factors that affect resorption. Additionally, little is known about nutrient resorption efficiency and proficiency of crop plants and they are usually focused on nitrogen [9, 10, 11].

In this study, it was hypothesized that leaf location and traffic-based pollution may affect P resorption efficiency and proficiency in *Cornus mass* L. (cornelian cherry) leaves. The study aimed to determine the differences in P concentrations between green and senescent leaves and variation in P resorption efficiency and proficiency in *C. mass* due to leaf location and traffic-based pollution. *C. mass* leaves were selected as materials because *C. mass* is a common crop in the study area and used as food both by humans and other organism. *C. mass* is not only used as foot but also for medicinal purposes. The study area is in Durağan, Sinop, which is famous with *C. mass* fruits of good quality. A study didn't found in the literature on resorption efficiency and proficiency of *C. mass* and effect of leaf location and traffic-based pollution on resorption efficiency and proficiency. Because the large part of the nutrient supply of plants is contained in the leaves, determining nutrient use efficiency and proficiency of leaves is important for plant growth and maintenance. Additionally, a crop plant was selected as a material because of the importance of study subject for healthy of organisms, agricultural economics and sustainability of agricultural ecosystems.

2 Materials and Method

The study area is in Durağan, Sinop in the Central Black Sea Region of Turkey. The study materials were *C. mass* leaves. *C. mass* is a deciduous shrub or small tree of about 7-8 m in height that belongs to Cornaceae family. A field study was carried out in two different *C. mass* orchards. One of the orchards was exposed to exhaust gases because of traffic and the other was away from the traffic. Ten individual *C. mass* plants were selected in both polluted and unpolluted orchards. Selected individual *C. mass* plants were marked and leaf samples were collected from them in green mature period (August) and senescence period (October). In order to determine the effect of leaf location on P resorption efficiency and proficiency, 20 close leaves to fruit and 20 away leaves from fruit were collected from each individual *C. mass*. Undamaged leaf samples were collected from same individual *C. mass* plants in green and senescence periods. Leaf samples were dried into a drying oven at 75 °C until constant weight was reached and milled. The microwave method was applied for milled leaf sample dissolution [12].

P concentrations were determined by ultra-violet spectrophotometric method [13]. P concentrations were calculated as mg g^{-1} dry weight (DW). P resorption efficiency (PRE) was calculated as:

$$PRE=((Pg-Ps)/Pg)\times 100$$

where Pg and Ps is the P content in green and senescing leaves per plant, respectively [13]. P resorption proficiencies (PRP) were determined as absolute residual N and P concentrations in senescent leaves as mg g^{-1} DW [5]. Soil samples weren't take into account and analysed because there no clear effect of nutrient avail- ability in soil on nutrient resorption [6, 14].

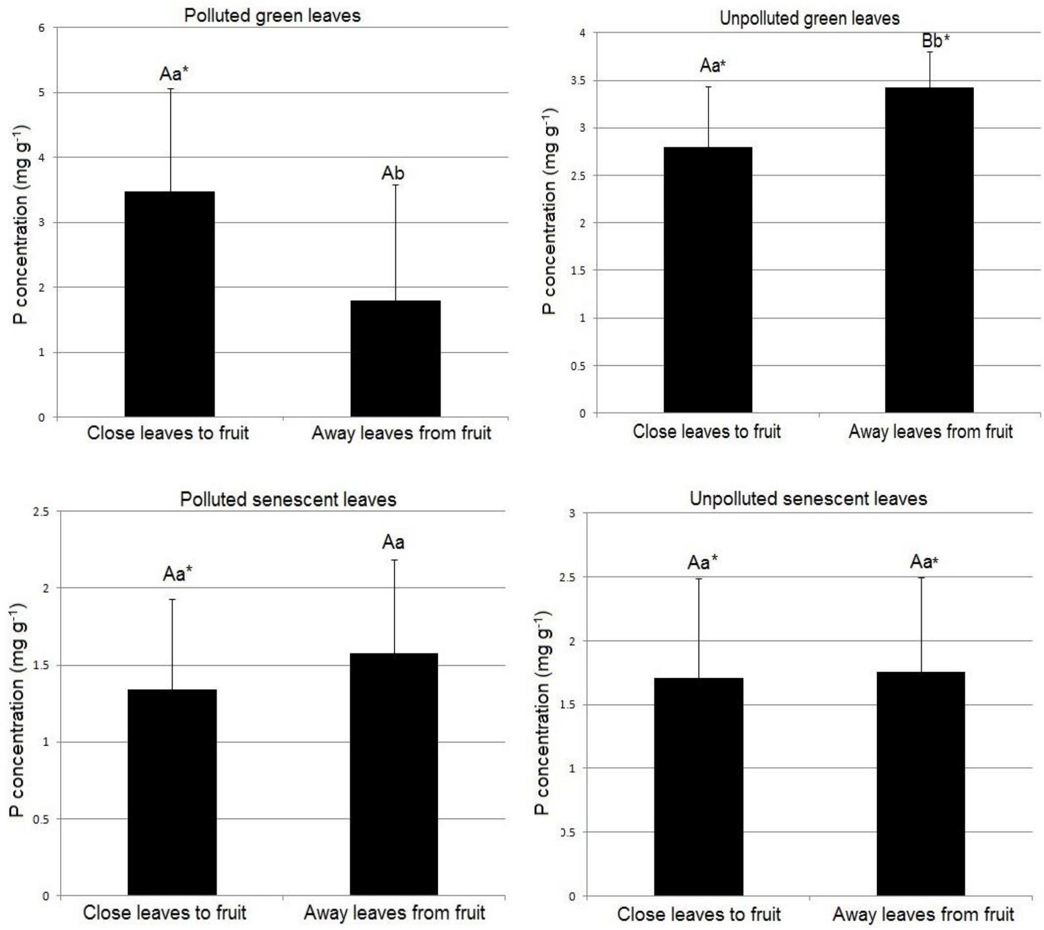

Figure 1. P concentration (mg g^{-1}) according to parameters. P concentration in senescent leaves indicates PRP. Capital letters indicates differences in P concentrations between polluted and unpolluted leaves. Small letters indicates differences in P concentrations between close leaves to fruit and away leaves from fruit. Differences in P concentrations between green and senescent leaves indicated with asteriks are significant at P≤0.05 level.

The statistical analyses were done using SPSS (Version 20). The Independent sample T- test was performed in order to determine the differences in P concentrations, P resorption efficiency and proficiency between parameters. Relationships between parameters were examined by Pearson correlation analysis. Relationships between PRE and P concentration in green leaves (Pgreen) and P concentration in senescent leaves (Psenescence) were determined by Regression analyses. Regression analyses were applied whole data set.

3 Results and Discussion

Variations in P concentrations between close leaves to fruit and away leaves from fruit according to leaf and pollution status were shown in Figure 1. While differences in P concentration between close leaves to fruit and away leaves from fruit were significant in both polluted and unpolluted green leaves, those were not significant in polluted and unpolluted senescent leaves. Only the difference in P concentrations between polluted and unpolluted leaves was significant in green away leaves from fruit. Except that of polluted away leaves from fruit, differences in P concentrations between green and senescent leaves were significant in other type of leaves. Mean P concentration in mature leaves of deciduous shrubs and trees were reported as 1.60 mg g^{-1} [14]. The P concentrations in mature green leaves obtained from the current study were higher than reported mean value.

P concentrations in senescent leaves also reflect NRPs. It means that NRP didn't significantly vary according to leaf location in *C. mass*. However, NRP values were lower in close leaves to fruit than away leaves from fruit. The lower NRP values indicate more proficiently P usages for plants in polluted and unpolluted leaves. The NRP values of *C. mass* leaves ranged between 1.34-1.76 mg g^{-1}. It was expressed that resorption is highly proficient in plants that have reduced phosphorus in their senescing leaves, with concentration below 0.05% [15]. Additionally, Killingbeck [15] reported that P concentration in senescent leaves that is more than 0.08% P indicates incomplete or low resorption proficiency. According to this generalisation, P was not used very proficiently in *C. mass* in the current study. This result of the study is important for agricultural activities such as plant nutrient status and fertilisation. If *C. mass* leaves could use P more proficiently, it would be less dependent on new nutrient uptake from the soil in the future growth period.

Figure 2 indicates the PRE values according to leaf location and pollution status. Neither in polluted leaves nor in unpolluted leaves differences in PRE values between close leaves to fruit and away leaves from fruit were not significant. However, PRE in close leaves to fruit was higher than away leaves from fruit in polluted leaves while unpolluted leaves had reverse situation. Differences in P use efficiency values between polluted and unpolluted leaves, and between close leaves to fruit and away leaves from fruit were not statistically significant (Table 1 and 2). PRE values ranged between 47.269-57.803% in *C. mass*. Aerts [14] reported mean P resorption efficiency for deciduous shrubs and trees as 50.4%. The PRE values obtained from the current study nearly correspond to this generalization. On average, about half of the P concentration in leaves can be reused by means of resorption process. By considering that the large part of the nutrient supply of plants is contained in the leaves, it may be said that resorption process is very important in plant nutrient conservation [14]. Resorption of nutrients enables plants to reuse nutrients and reduce their dependency to new nutrient uptake. Efficiently and proficiently usages of nutrients provide selective advantage to plants, especially for crops. By means of resorption mechanism plants can use reabsorbed nutrients directly in the new growth season.

Significant relationships were found between P concentrations and closeness to fruit, pollution status and leaf status (Table 3). There were a positive and a negative relationship between P concentration and closeness to fruit in unpolluted green leaves and polluted green leaves, respectively. This contrast may be resulted from differences in element contents between polluted and unpolluted leaves. A negative relationship was determined in away green leaves from fruit between P concentration and pollution status of leaves. Negative relationships were found between P concentrations and leaf status in close polluted and unpolluted leaves to fruit and away unpolluted leaves from fruit.

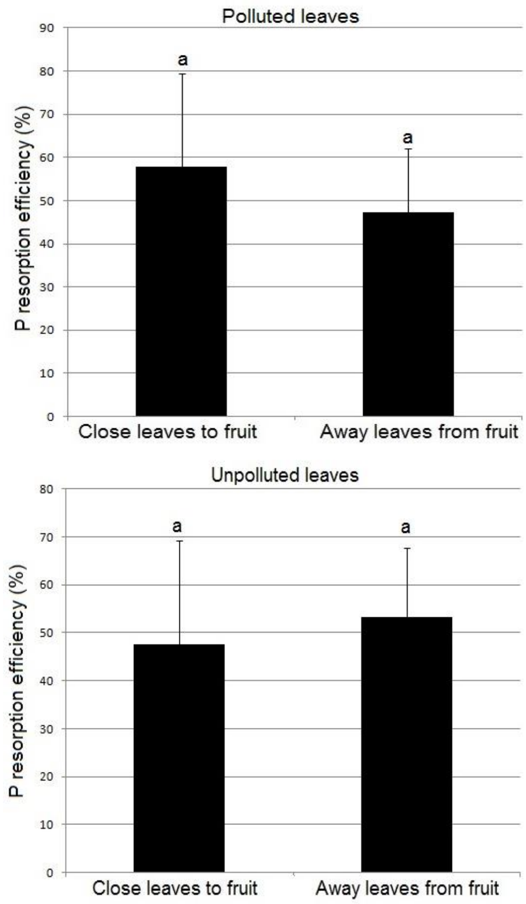

Figure 2. PRE (%) according to parameters.

Table 1. Differences in P use efficiency between polluted and unpolluted leaves.

P Resorption Efficiency	F	t	df	P
Close leaves to fruit	0.001	-1.057	18	0.305
Away leaves from fruit	0.208	0.905	18	0.377

Table 2. Differences in P use efficiency between close leaves to fruit and away leaves from fruit.

P Resorption Efficiency	F	t	df	P
Polluted leaves	2.967	1.269	18	0.221
Unpolluted leaves	1.924	-0.685	18	0.502

Table 3. Relationships between P concentrations and closeness to fruit, pollution status and leaf status

	Closeness to fruit	**Pollution status**	**Leaf status (green or senescent)**
	Unpolluted green leaves	Close green leaves to fruit	Close unpolluted leaves to fruit
P (mg g^{-1})	0.532*	0.284	-0.631**
	Unpolluted senescent leaves	Away green leaves from fruit	Close polluted leaves to fruit
P (mg g^{-1})	0.036	-0.753**	-0.688**
	Polluted green leaves	Close senescent leaves to fruit	Away unpolluted leaves from fruit
P (mg g^{-1})	-0.559*	-0.272	-0.830**
	Polluted senescent leaves	Away senescent leaves from fruit	Away polluted leaves from fruit
P (mg g^{-1})	0.205	-0.143	-0.136

* Correlation is significant at the 0.05

** Correlation is significant at the 0.01

No significant relationship was found in P concentration between green and senescent leaves. A negative significant relationship was found between PRE and P concentration in senescent leaves by a power equation (Figure 3). A positive linear relationship was determined between PRE and P concentration in green leaves. In contrast, Kobe et al. [16] reported that P resorption efficiency decreased with increased P green leaf status. Decrease in resorption efficiency based on increasing green leaf nutrient concentration may be explained by that under higher fertility conditions, nutrient uptake from soil may be relatively less expensive than reabsorption of nutrients [16]. However, results of the current study showed that it may be regulated based on costs of nutrient uptake from the soil and reabsorption of nutrients from senescencing leaves.

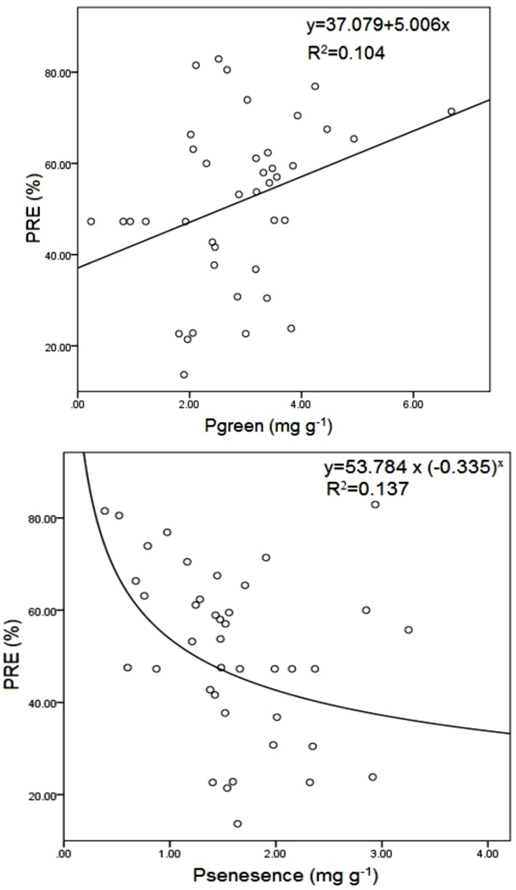

Figure 3. Relationship between PRE and P concentration in green leaves (Pgreen) and P concentration in senescent leaves (Psenescence).

4 Conclusion

As a conclusion differences in P concentration according to leaf location was only significant in green leaves. A significant variation was found only in away green leaves from fruit between polluted and unpolluted leaves. Except that of polluted away leaves from fruit, differences in P concentrations between green and senescent leaves were significant in other type of leaves. PRP didn't significantly vary according to any of the parameters. Both in polluted and unpolluted leaves, differences in PRE values between close leaves to fruit and away leaves from fruit were not significant. The results of the study showed that *C. mass* leaves efficienctly use P while their P resorption proficiency was low. Half of the P content in *C. mass* leaves was reabsorbed from senescent leaves and this enables it an advantage in next growth season. This is important for nutrient conservation of plants, especially in crop plants. This is also important for sustainability of ecosystems.

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