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The effect of Aminoethoxyvinylglycine (AVG) applications on mineral contents of grape leaves

Aminoetoksivinilglisin (AVG) uygulamalarının üzüm yapraklarının mineral içeriğine etkisi

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ABSTRACT

Plant growth regulators may have different physiological effects depending on the application stage and concentration when applied externally. In this study, it was aimed to determine the effects of pre-harvest aminoethoxyvinylglycine applications on the mineral contents of *Vitis vinifera* L. cv. Alphonse Lavallée leaves. AVG was applied to vines at five different concentrations (0, 250, 500, 750 and 1000 mg L^{-1}) and two application stages (at full bloom and fruit set). As a result, the effects on macro elements content of the grapevine of AVG applications were significant except P. In terms of microelement contents, generally, microelement contents were increased with the AVG applications, only the amount of Fe decreased with the AVG applications. For this reason, AVG plant growth regulator is thought to have both increasing and decreasing effects on the mineral element contents of Alphonse Lavallée leaves.

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ÖZ

Bitki büyüme düzenleyicileri, dışsal olarak uygulandığında uygulama zamanına ve konsantrasyonuna bağlı olarak farklı fizyolojik etkilere sahip olabilmektedirler. Bu çalışma ile hasat öncesi aminoetoksivinilglisin uygulamalarının *Vitis vinifera* L. cv. Alphonse Lavallée üzüm çeşidinin yapraklarındaki mineral besin elementi içeriği üzerindeki etkilerinin belirlenmesi amaçlanmıştır. AVG uygulamaları asmalara beş farklı konsantrasyonda (0, 250, 500, 750 ve 1000 mg L^{-1}) ve iki farklı uygulama zamanında (tam çiçeklenme dönemi ve meyve tutumu döneminde) uygulanmıştır. Araştırmanın sonucunda, AVG uygulamalarının asmalarının makro element içeriği üzerindeki etkileri, P hariç önemli bulunmuştur. Mikro element içeriği bakımından ise, genel olarak mikro element içeriklerinin AVG uygulamaları ile arttığı, buna karşılık sadece Fe miktarının azaldığı tespit edilmiştir. Bu nedenle, AVG bitki büyüme düzenleyicisinin Alphonse Lavallée yapraklarının mineral element içerikleri üzerinde hem artan hem de azaltıcı etkileri olduğu düşünülmektedir.

1. Introduction

Plant growth regulators naturally produced by plants or synthesized in laboratories are organic compounds that control and modify physiological processes such as plant growth, development and movement and can be effective even at very low concentrations (Sezgin and Kahya 2018). Ethylene is a plant hormone that plays a role in various physiological processes such as germination, flowering, plant growth, dormancy, fruit set, maturity, softening and senescence affects the plant development during the whole life (Khan et al. 2015; Öztürk et al. 2015). Senescence-promoting property of ethylene limits flower life during flowering and decreases fruit set (Öztürk et al. 2015). Although ethylene levels seem much lower than climacteric fruits, there is evidence that minor changes in ethylene and CO_2 evolution may occur during ripening in some non-climacteric fruits such as grapes. Thus, the role of ethylene in non-climacteric fruits, especially fruit ripening, has recently been revised again (Böttcher et al. 2013). Ruperti et al. (2001) stated that the ethylene increase during flowering is associated with a rise of 1-aminocyclopropane-1-carboxylic acid (ACC) and the ACC oxidase (ACO) activity. Also, they pointed out that at the beginnings of grapevine flowering, the ACO activity increases significantly and persisted at a high and steady level until the end of abscission. This enzyme was thought to play a major role in grapevine floral abscission.

Aminoethoxyvinylglycine (AVG) is a potent ethylene biosynthesis inhibitor that inhibits the conversion of S-adenosyl methionine (SAM) to (ACC) (Çetinbaş and Butar 2013; Ünsal and Yıldırım 2017). In recent years, AVG has been used to increase pre-harvest fruit fall and fruit quality. Pre-harvest application of AVG affects ripening, abscission, and senescence by inhibiting the biosynthesis of ethylene and also reduces quality loss after harvest in many crops (Pech et al. 2012; Küçüker et al. 2015; Çetinbaş 2018). Hilt and Bessis (2003) stated that the ethylene increase during grapevine flowering was associated with a similar increase in ACC and the ACO activity. Hu et al. (1999) found that AVG application before flowering in grapevines reduces ACC content in flowers. In addition to these effects of AVG on fruit set and quality, the determination of possible effects on nutrient content will provide more detailed information about the physiological status of the vines. In this study, the effects of AVG concentrations applied during the full bloom and fruit set on the mineral content of the leaves were investigated in Alphonse Lavallée grape cultivar.

2. Material and Methods

The experiments were carried out in a commercial vineyard in Gönen-Isparta-Turkey. Uniform 9-years old *Vitis vinifera* L. cv. Alphonse Lavallée grafted on 41 B M.G. rootstocks, spaced 2x3 m were used. Vines were trained on a bilateral cordon system and standard cultural practices had been used regularly during the trial. In the study, AVG (ReTain (15% AVG) Valent BioScience Corporation) at five different concentrations (0, 250, 500, 750 and 1000 mg L^{-1}) was applied to the vines. AVG concentrations were calculated based on the active substance. These doses were applied to vines at full bloom and fruit sets. AVG solutions contained 0.1% (v/v) Tween 20 as a surfactant. Control vines were sprayed with water added Tween 20. A pump sprayer was used for spraying directly onto the vines (1 L per vine). AVG applications were given in Table 1. When the grapes were at commercial maturity, leaves were collected from the sixth to twelfth leaves on the shoot counted from the base (Hallaç Türk 2009). The collected leaves were immediately transferred to the laboratory and washed with distilled water and then dried in an oven at 45°C oven until the constant mass is achieved. They were kept in the desiccator until the analyses.

Table 1. AVG applications.

Applications	AVG concentrations (mg L^{-1})	Application stage
1	Control	-
2	250	full bloom
3	500	full bloom
4	750	full bloom
5	1000	full bloom
6	250	fruit set
7	500	fruit set
8	750	fruit set
9	1000	fruit set

2.1. Determination of the leaf mineral element contents

Total nitrogen (N) concentrations were determined according to the Kjeldahl method. The phosphorus (P) concentrations of the leaves were determined by a spectrophotometer at 430 nm according to the vanadomolybdophosphoric acid method. Potassium (K), calcium (Ca), magnesium (Mg), iron (Fe), copper (Cu), zinc (Zn), manganese (Mn) and boron (B) concentrations were determined using atomic absorption spectrophotometer (Kaçar and İnal 2010).

2.2. Statistical analysis

The collected data were subjected to statistical analysis using a randomized complete block design. Statistical analyses were performed using SSPS V.25. Mean values were compared using Duncan's multiple range test at $p \leq 0.05$ level. Each treatment was designed with three replicates consisting of five vines.

3. Results and Discussion

As illustrated in Figure 1, the effect of AVG applications on the contents of the macro element except for the P of leaves was found to be statistically significant ($p<0.05$). Nitrogen contents increased with 1000 ppm AVG applications in the full bloom stage. In the stage of fruit set, all AVG concentrations caused a decrease in nitrogen content (Figure 1a). Nitrogen is an important nutrient required for plant growth and development as it is a core constituent of a plant's nucleic acid, proteins, enzymes, and cell wall and pigment system (Khan et al. 2015). For this reason, in this study, it can be said that the increase in the amount of N in the leaves as a result of AVG applications performed especially during the full bloom period can positively affect the growth of the shoots and stimulate vegetative development in the vine. Çetinbaş (2018) also mentioned that a positive correlation was detected between N content and AVG applications in pear leaves. The amount of P was found to be statistically insignificant (Figure 1b). Phosphorus is needed for the formation of cell membranes, carbohydrate metabolism, protein synthesis, photosynthesis, respiration, sugar metabolism, energy carriers such as ATP (Brunetto et al. 2015). In this study, it has been determined that AVG applications did not affect the P accumulation in leaves. Similarly, Çetinbaş (2018) stated that AVG applications did not statistically affect P accumulation in fruits and leaves. In terms of K contents, the amount of K increased with the AVG applications in general. The highest K content was obtained through the use of 750 mg L^{-1} of AVG at the fruit set stage (Figure 1c). Plants, in general, take up an amount of K greater than their metabolic needs and accumulated it into cell organelles in luxury consumption (Brunetto et al. 2015). However, the optimum K level also depends on the balance between N and K in the leaves. It is determined that when plants have proportionally high N and low K content, pathogen attacks increase (Bergmann 1992). In this study, AVG applications affect K contents in different ways in leaves. Concerning the effect of AVG applications on Ca, calcium content was changed between 1.68 and 2.78%. The highest Ca content was obtained with 500 mg L^{-1} of AVG at fruit set stage (Figure 1d). It is known that applications promoting vegetative development negatively affect Ca content in the plant (Atay et al. 2016). As a matter of fact, it has been determined that AVG application, which is the highest in terms of N accumulation, is the lowest in terms of Ca accumulation. The effect of AVG applications was statistically significant on the Mg of leaves as well. According to this, the highest Mg contents were recorded from the vines treated with 1000 mg L^{-1} of AVG at fruit set stage while the lowest values detected from the vines were treated with 1000 mg L^{-1} of AVG at full bloom stage (Figure 1e). Some authors have indicated antagonism between both Mg and K (Paulo and Furlani 2010). According to this, as the K content of the plant increases, their needs for Mg increase. Such results were confirmed in the herein study,

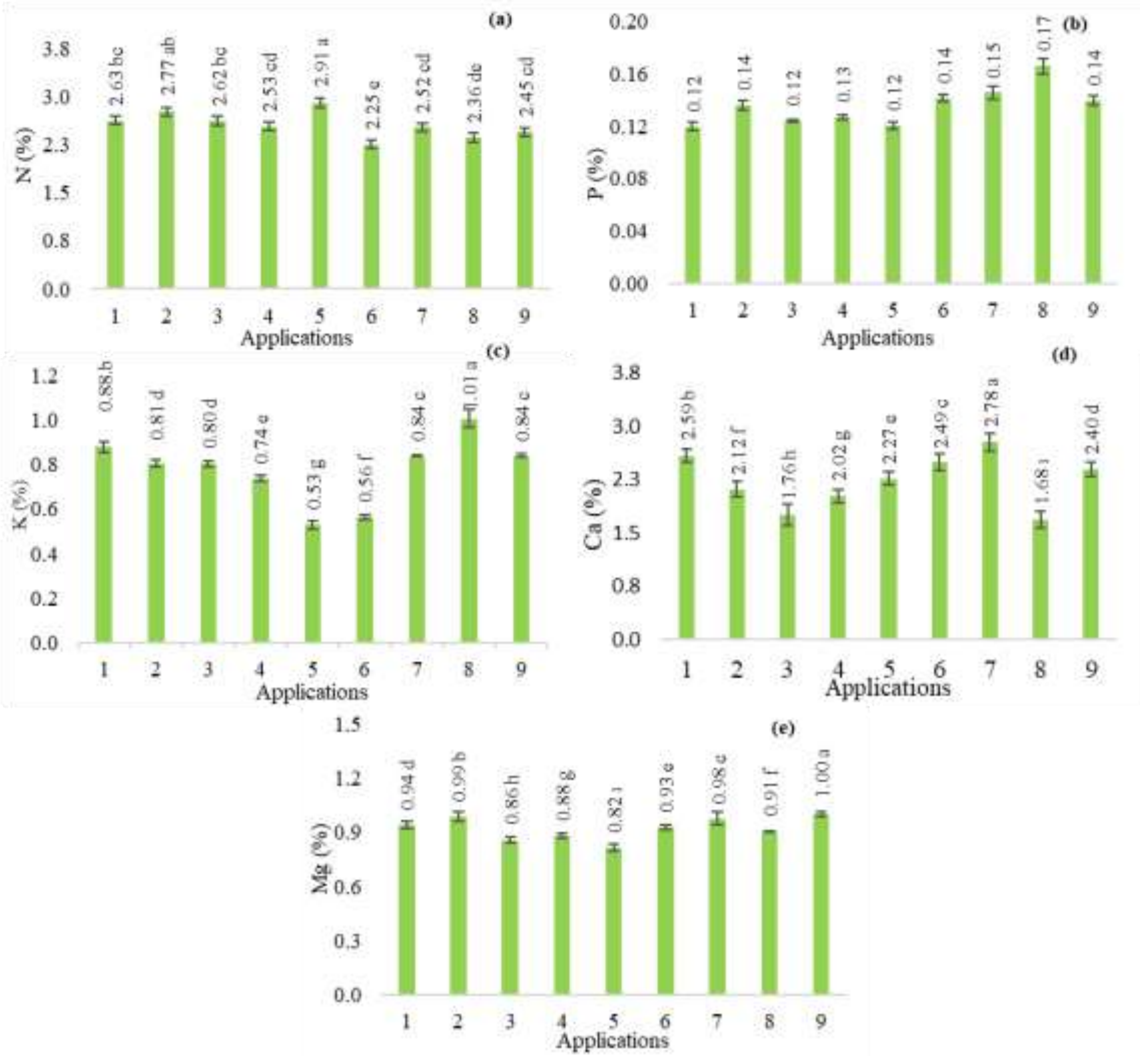

Figure 1. The effects of AVG treatments on macro elements in Alphonse Lavallée grapevine leaves a) N, b) P, c) K, d) Ca, e) Mg.

evidenced by the negative correlation observed between leaves K and Mg concentrations.

Microelements are of great importance because of their role in various metabolic processes, enzymatic processes, and also processes that determine the quality of viticulture products (Sala and Blidariu 2012). Figure 2 shows the effect of AVG applications on the Fe, Cu, Zn, Mn and B contents of the leaves. The effect of AVG applications on all microelements contents of leaves was found to be statistically significant ($p<0.05$). In terms of Fe contents, the amount of Fe decreased with the AVG applications. Iron content had the highest value in the control treatment (Figure 2a). Aglar et al. (2016) mentioned that AVG treatments increased leaf Mn and K contents, decreased Fe and N contents and did not result in significant changes in the other nutrients. Also, Çetinbaş (2018) stated that AVG plant growth regulator is thought to have both increasing and decreasing effects on the mineral element contents in the fruits and leaves of Akça pear. It was determined that 750 mg L^{-1} AVG applications at the fruit set stage lead to significant increases in the amounts of Cu (Figure 2b). Similarly, when the study of Çetinbaş (2018) is examined, it was seen that the AVG applications increased the Cu content. Copper is an essential micronutrient that is important to plants as a constituent of several enzymes and as a redox catalyst in a variety of metabolic pathways (Devez et al. 2005). Also, Since the late 19th century, Bordeaux mixture [$CuSO_4$+$Ca(OH)_2$], a fungicide containing Cu, has been widely applied on vineyards to control downy mildew in vine growing areas and is therefore of great importance in viticulture (Lai et al. 2010). Zinc was found to be significantly affected by treatments and the highest value was detected from the leaves applied with 250 mg L^{-1} of AVG at the fruit set stage (Figure 2c). Zn was reported to play a significant role in auxin metabolism (Kramer and Clemens 2006). Different results were reported by previous researchers about the effects of AVG on leaves Zn content (Aglar et al. 2016; Çetinbaş 2018). As illustrated in Figure 2d and Figure 2e, Mn and B contents of the leaves increased in the full bloom stage. For Mn and B, the highest values were obtained 250 mg L^{-1} and 750 mg L^{-1} of AVG, respectively. Boron, improve fruit-set, increase the fertilization of seeds, and enlarge berry size. Christensen et al. (2006) stated that when B fertilizer is sprayed on leaves, it is taken in more effectively by the plant and especially reduces fruit set deficiency symptoms in Thompson seedless grapes.

Butar (2013) applied different AVG doses to Jersey Mac apples and indicated that AVG treatments did not have significant effects on fruit micro and macro elements. Contrarily in this study, AVG treatments had significant effects on all microelements and N, K, Ca and Mg-like macro elements.

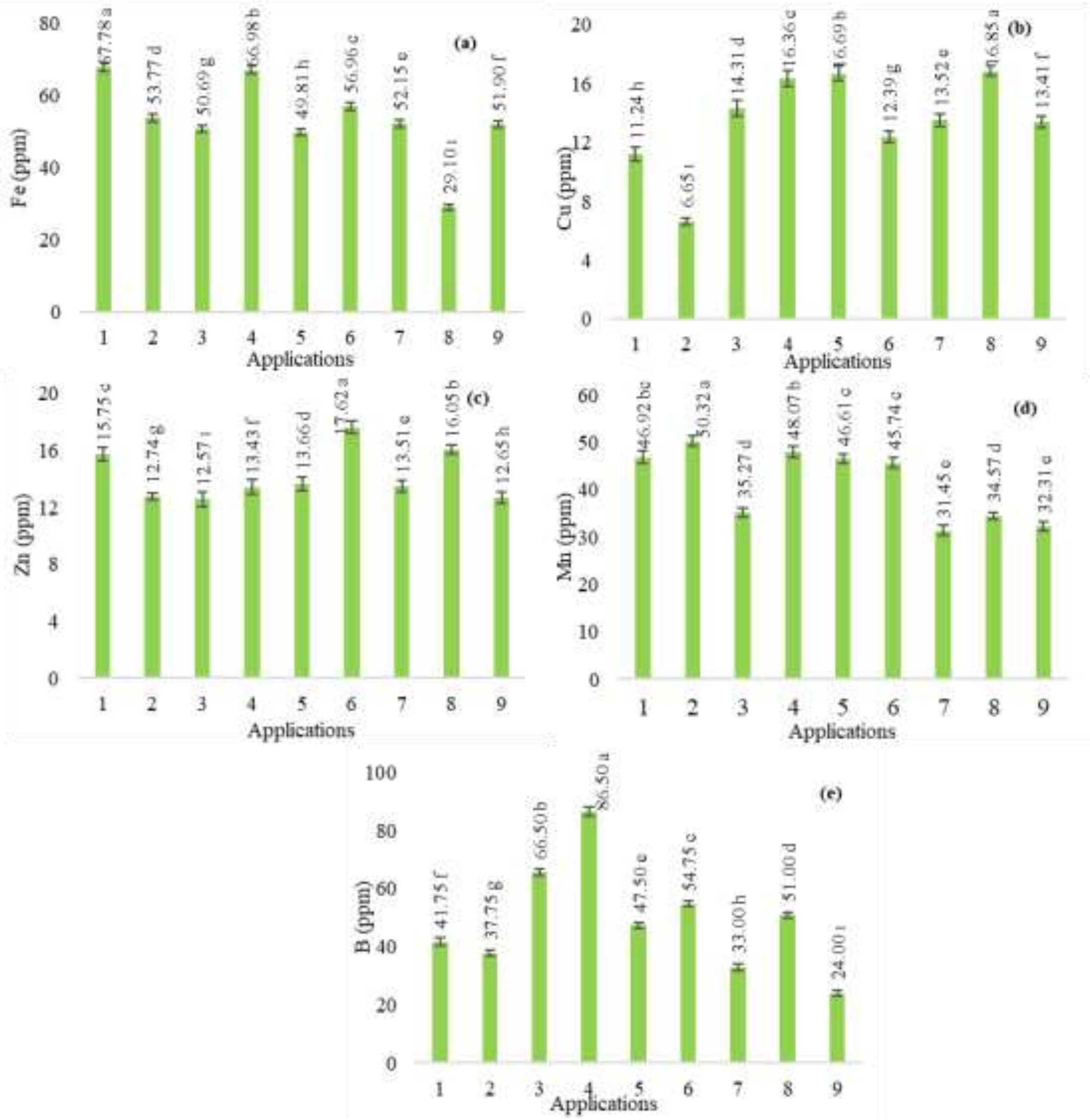

Figure 2. The effects of AVG treatments on microelements in Alphonse Lavallée grapevine leaves a) Fe, b) Cu, c) Zn, d) Mn, e) B.

4. Conclusion

When the results are analyzed, it is concluded that AVG causes significant increases in the mineral content of Alphonse Lavallée grapevine leaves in this study. In general, the best results were obtained from the high concentrations of AVG at the fruit set stage for Alphonse Lavallée grape cultivar in terms of, especially microelements. However, more detailed studies are needed in this regard, as plant nutrients interact with plant growth regulators.

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