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Plant Growth Regulator Use in Temperate Zone Fruit Trees against Abiotic Stresses

Ilıman İklim Meyve Ağaçlarında Abiyotik Streslere Karşı Bitki Büyüme Düzenleyicilerin Kullanımı

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Abstract **–** Plants encounter a variety of environmental stress factors that affect plant growth, fruit yield and quality. Stress factors cause physiological dysfunctions, ion imbalance, depression in photosynthesis, leading to growth reduction and decrease in fruit quality and taste. Recent studies have focused on the plant growth regulators to trigger plant tolerance to various environmental stresses. Plant growth regulators such as salicylic acid (SA), glycine betaine (GB), silicon (Si), sodium nitroprusside (SNP), proline have been found to play an important role in plant responses to stress factors. SA plays an important role in the regulation of plant growth, development and responses to abiotic stresses. Silicon nutrition has been shown as an important application to mitigate environmental stresses. Moreover, SNP is involved in many processes of plants such as induction in cell death, stomatal movement, photosynthesis and floral regulation. In the current review, useful effects of the plant growth regulators on temperate zone fruit trees against many stress factors will be discussed.

Keywords – Abiotic Stress, Fruit Tree, Plant Growth Regulator, Phytohormone, Salicylic Acid

Özet– Bitkiler, büyümeyi, meyve verim ve kalitesini etkileyen çevresel stres faktörleriyle karşılaşmaktadır. Stres faktörleri fizyolojik işlev bozukluklarına, iyon dengesizliğine, fotosentezde gerilemeye sebep olup bunlar da büyümede azalmayı ve meyve kalite ve tadında kayıpları yaşatmaktadır. Son yıllardaki çalışmalar çevresel streslere karşı bitki toleransını sağlaması amacıyla bitki büyüme düzenleyicilerine odaklanmıştır. Salisilik asit (SA), glisin betain (GB), silisyum (Si), sodium nitroprussit (SNP), prolin gibi birçok bitki büyüme düzenleyicisi stress faktörlerine karşı bitkilerin verdiği tepkilerde büyük bir rol oynamaktadır. SA bitki büyümesi ve gelişimi ve abiyotik streslere karşı tepkilerin düzenlenmesinde önemli bir rol üstlenmektedir. Si besini çevresel stresleri azaltmada oldukça önemli bir uygulamadır. Ayrıca, SNP bitkide hücre ölümü, stoma hareketi, fotosentez ve çiçeklenmenin düzenlenmesi gibi birçok işlemde görev almaktadır. Bu derlemede ılıman iklim meyve türlerinde bitki büyüme düzenleyicilerin stres faktörlerine karşı faydalı etkileri tartışılacaktır.

Anahtar Kelimeler – Abiyotik Stres, Meyve Ağacı, Bitki Büyüme Düzenleyicisi, Prolin, Salisilik asit

I. INTRODUCTION

Many environmental stress factors such as drought, low temperature, salinity occur in plant growing areas that limit fruit yield and quality in many crops. Salinity is one of the major environmental stresses in arid, semi-arid and seaside regions due to the poor drainage, excessive fertilization and coastal areas. Crops growing in calcareous soils face iron (Fe) deficiency-induced chlorosis. Furthermore, plants grown in temperate zones encounter cold damage due to low temperature. Decline in plant growth under stress conditions has been reported for many fruit species [1, 2, 3, 4, 5, 6].

The plants reveals many physiological and biochemical responses to manage the malignant effects of stresses, such as accumulation of proline, glycine betaine, synthesizing of antioxidants against ROS [7]. Therefore, increase of defense mechanisms in plants is necessary for improving the tolerance to stresses. Mechanisms of plant tolerance against stress factors are not yet completely clear. Finding suitable stress alleviants may help plants to acquire tolerance. Several plant regulators are used in many plants to protect from environmental damages. The plant growth regulators (also known as growth regulators or plant hormones) are chemicals used to alter the growth of a plant. Generally, plant hormones (phytohormones) are known as plant growth regulator, however, many biochemicals and nutrients such as glycine betaine (GB), silicon (Si), proline take roles in plant growth under stress conditions [8, 9]. Furthermore, some regulators shown in Table 1 are known as osmoprotectant which accumulates under stress conditions and maintains osmotic adjustment [10].

Table 1. Major regulators showing stress-tolerances in temperate fruit trees

Regulator	Species	Stress	Reference
methyl jasmonate	*Prunus persica*	High temperature	11
gamma aminobutyric acid	*Prunus avium*	root hypoxia	12
glycinebetaine	*Malus robusta*	drought	13
Melatonin	*Malus hupehensis*	Alkaline	14
Ascorbic acid	*Prunus armeniaca*	Chilling injury	15
Salicylic Acid	*Prunus wilsonii*	Low temperature	16
melatonin	*Malus hupehensis*	salinity	17
polyamines	*Malus hupehensis*	cadmium chloride	18
sodium nitroprusside	*Malus hupehensis*	Water stress	19

The current review will summarize the plant growth regulators on temperate fruit trees under many stress conditions.

II. EXOGENOUS PLANT GROWTH REGULATORS TO MITIGATE STRESS DAMAGES

Many experiments have shown that plant growth regulators provided significant influences on plants against stress factors. These regulators increases stress tolerance by distinct mechanisms.

Salicylic Acid

Salicylic acid (SA) is a naturally occurring plant hormone, affects many physiological and biochemical responses in plants, acts as an important signaling molecule and has diverse effects on tolerance to environmental stresses [20]. For fruit trees, the information of the SA-induced stress tolerance is still limited, however many experiments with SA were conducted on fruit quality and storage in temperate fruits. In a previous study, peach fruits were immersed in SA solution and shelf life was evaluated. They thought the effect of SA on mitigating chilling injury of peaches during cold storage may be its ability to induce antioxidant systems [21]. Moreover, Yao and Tian [22] have shown that pre-harvest treatment with 2 mM SA increased cherry fruit storage.

Melatonin

Melatonin, a low-molecular-weight molecule, acts as a growth regulator, similar to the role of indole acetic acid (IAA), in directing the differentiation of cells, tissues, and organs [23]. It also protects plants against damage caused by environmental stresses such as heavy metals, temperature fluctuations [17].

Glycine Betaine

Glycine betaine (GB), one of the most effective osmoprotectants, accumulates in many plant species under stress conditions. Glycine betaine (GB) protects thylakoid and plasma membrane integrity after exposure to salt stress and high temperature[10]. Zhang et al. [13] reported that GB application decreased malondialdehyde content, product of lipid peroxidation, under drought condition and determined 100 mg L^{-1} GB is the appropriate dose for the experiment.

Sodium Nitroprusside

Nitric oxide (NO) and its donors such as sodium nitroprusside (SNP), S-nitro-Nacetylpenicillamine (SNAP) help plant growth and development under stress conditions [24]. In previous studies, it has been demonstrated that NO is involved in many processes of plants such as induction in cell death, stomatal movement, photosynthesis regulation [25, 26].

III. CONCLUSION

Temperate zone fruit trees are exposed many environmental stress factors that decline fruit yield quality. Several plant growth regulators, protectants can be applied to plants in order to gain tolerance against stresses. Thus, biochemical must be known deeply, their mechanisms in plants should be studies and be applied to plants with appropriate dose.

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