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AN APPROACH ON ALUMINUM TOLERANCE MECHANISMS AND THE MITIGATING ROLE OF SILICON IN POPCORN

Presidente Prudente - SP
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“Aqueles que passam por nós,

não vão sós,

não nos deixam sós.

Deixam um pouco de si,

levam um pouco de nós.”

(Antoine de Saint-Exupéry)

UMA ABORDAGEM SOBRE OS MECANISMOS DE TOLERÂNCIA AO ALUMÍNIO E PAPEL MITIGADOR DO SILÍCIO EM MILHO PIPOCA

RESUMO

O cultivo de milho pipoca (*Zea mays* L. var. everta) é amplamente destinado ao consumo humano, mas sua produtividade pode ser afetada em solos ácidos, onde a toxicidade do alumínio (Al) é um problema. No primeiro experimento, investigamos os efeitos do Al em duas linhagens de milho pipoca: 11-133, tolerante ao Al, e 11-60, sensível ao Al. Observamos que o Al não afetou o crescimento da parte aérea, mas causou amarelecimento na lâmina foliar mais velha da linhagem sensível. A linhagem 11-133 apresentou mecanismos de quelação de Al, resultando em menor alteração na estrutura radicular e menor presença de espécies reativas de oxigênio (EROs) e malondialdeído (MDA), o que doi atribuído a um sistema enzimático mais eficiente, principalmente devido ao metabolismo da glutationa (GSH). No segundo experimento, investigamos o papel mitigador do silício (Si) frente ao Al em plantas de milho pipoca. Observamos que na presença de Al houve redução da taxa de crescimento das raízes, mas a adição de Si mitigou esse efeito negativo, resultando na redução da concentração de Al nas pontas de raízes e em menor impacto morfoanatômico. O Si também modulou o metabolismo das plantas expostas ao Al, aumentando as concentrações de frutose, sacarose, aminoácidos totais e nitrato, enquanto as concentrações de proteínas totais diminuíram nas plantas tratadas com Si. Esses resultados indicam o potencial do Si como uma estratégia para melhorar o desenvolvimento de culturas em solos ácidos e mitigar os efeitos negativos da toxicidade do Al em plantas de milho pipoca.

Palavras-chave: Toxicidade por alumínio; morfologia da raiz; sistema antioxidante, ácidos orgânicos, metabolismo primário.

AN APPROACH ON ALUMINUM TOLERANCE MECHANISMS AND THE MITIGATING ROLE OF SILICON IN POPCORN CORN

ABSTRACT

The cultivation of popcorn maize (*Zea mays* L. var. everta) is widely intended for human consumption, but its productivity can be affected in acidic soils, where aluminum (Al) toxicity is a problem. In this study, we investigated the effects of Al on two popcorn maize lineages: 11-133, Al-tolerant, and 11-60, Al-sensitive. We observed that Al did not affect the shoot growth, but it caused yellowing in the older leaf blade of the sensitive lineage. The tolerant lineage showed Al chelation mechanisms, resulting in minor alterations in the root structure and lower presence of reactive oxygen species (ROS) and malondialdehyde (MDA), which is attributed to a more efficient enzymatic system, mainly due to the glutathione (GSH) metabolism. In the second experiment, we investigated the mitigating role of silicon (Si) against Al in popcorn plants. We observed that in the presence of Al there was a reduction in the root growth rate, but the addition of Si mitigated this negative effect, resulting in a reduction in the Al concentration in at root tips and a lower morphoanatomical impact. Si also modulated the metabolism of plants exposed to Al, increasing fructose, sucrose, total amino acids, and nitrate concentrations, while total protein concentrations decreased in Si-treated plants. These results indicate the potential of Si as a strategy to improve the development of crops in acidic soils and mitigate the negative effects of Al toxicity on popcorn plants.

Keywords: Aluminum toxicity; root morphology; antioxidant system, primary metabolism, organic acid, primary metabolism.

SUMMARY

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Article II

Histochemical, microscopic and metabolic responses of silicon as a mitigating agent of aluminum toxicity in popcorn seedling root tips

ABSTRACT

The toxicity of aluminum (Al) in acid soils impairs plant growth, however silicon (Si) can attenuate this toxic effect. the aim of this study was to investigate the short-term effects of Si as an attenuator of Al toxicity in popcorn (*Zea Mays* L. var. *Everta*) root tips. To achieve this, the mechanisms through which Si could alleviate the detrimental effects of Al were investigated, encompassing physiological, metabolic, and morphological traits. The treatments consisted of exposing the plants to the absence and presence of Al (200 μM) and the absence and presence of Si (2 mM). The results showed that the presence of Al reduced the root growth rate, evidencing its toxic effect. However, Si was able to mitigate this negative effect, induced a lower rate of root elongation. Furthermore, Si reduced the Al concentration in the roots, indicating its ability to bind Al in the nutrient solution, and consequently reducing the absorption of this toxic metal by the plants. The morphoanatomical analysis of the roots revealed that Si mitigated the alterations induced by Al, such as the increase in the radial diameter of the root tip, desquamation of the root apex cells and disorganization of the epidermal cells. These changes suggest that Si benefits the morphology of roots exposed to Al. In the metabolism of plants, the addition of Si resulted in increases in the concentrations of fructose, sucrose, total amino acids and nitrate. However, total protein concentrations decreased in plants treated with Si in the presence of Al. In summary, this study demonstrated that Si attenuates the toxic effects of Al in popcorn plants. These results highlight the beneficial potential of Si as a strategy to improve crop development in acidic soils and mitigate the negative effects of Al toxicity.

Keywords: Al and Si uptake; oxidative stress; root growth; C and N metabolism.

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