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镉胁迫对芥蓝根系质膜过氧化及ATPase活性的影响

Effects of cadmium on lipid peroxidation and ATPase activity of plasma membrane from Chinese kale (*Brassica alboglabra* Bailey) roots

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中文摘要:

水培条件下,以"香港白花"芥蓝品种为供试材料,研究4种不同浓度镉(0、1.0、2.0、4.0、8.0 mg/L Cd)处理对芥蓝幼苗根系质膜过氧化及ATPase活性的影响。结果表明,与对照相比,随着Cd处理浓度的增加,芥蓝根系活力呈现降低的变化趋势,而根系超氧化物歧化酶(SOD)、过氧化物酶(POD)和过氧化氢酶(CAT)活性以及丙二醛(MDA)、H_2O_2含量和O_2^-产生速率表现出升高的趋势,表明芥蓝受到活性氧物质的胁迫。1.0、2.0 mg/L Cd浓度处理下的H_2O_2含量与对照差异不显著,而O_2^-产生速率则在1.0 mg/L浓度处理下与对照差异不显著。随着Cd处理浓度的增加,芥蓝根系质膜H^+-ATPase和Ca^{2+}-ATPase活性呈现出先增后减的变化趋势。1.0 mg/LCd浓度处理时,H^+-ATPase和Ca^{2+}-ATPase活性与对照差异不显著($P > 0.05$),而在2.0、4.0、8.0 mg/LCd处理时,两种ATPase活性显著降低($P < 0.05$),并且与膜脂过氧化水平呈极显著的负相关($R^2 > 0.969$)。因此,低浓度Cd处理对芥蓝根系质膜两种ATPase活性影响较小,较高浓度Cd处理使芥蓝根系活力和质膜ATPase的损伤加重。

English Summary:

Cadmium (Cd) is among the most widespread and toxic pollutants in the surface soil layer. Its toxicity in soil is becoming a severe threat to organisms worldwide. It is the most dangerous carcinogen for the human body, and readily accumulates in kidneys and bones, leading to disruption of kidney function, osteomalacia and bone breakage. Wide areas of agricultural soil across China are heavily contaminated by Cd and thus it enters the food chain. In soil, Cd is distributed mainly in the topsoil and, without deposited by soil organic compounds, it is more easily assimilated by crop roots compared with other heavy metals. However, vegetable cultivars accumulate much more Cd in the shoot, the portion eaten by humans. In China, total vegetable production is 3.45 million tones, which ranks as the highest in the world, and most of the vegetable-farming land is located in suburban areas where highly intensive industries are located and thus the lands are widely contaminated by heavy metal pollutants. As a result, vegetables in most city markets contain Cd at levels two- to three-fold, or in extreme cases 5.2-fold, higher than the National Sanitary Criteria of Cd content in vegetable products. Economically, the heavy metal problem weakens the international competitiveness of the Chinese vegetable industry, therefore decontamination of heavy metals from polluted soils, as well as lowering of Cd residues in vegetables, is of great urgency both for human health and the national economy. Hydroponic experiments were conducted in a greenhouse to study the effects of Cd on lipid peroxidation and membrane proton pump activity of Chinese kale (*Brassica alboglabra* Bailey) roots, and to explore the toxicity of Cd stress on plants. Plants were grown under controlled environmental conditions, and subjected to different Cd concentrations ranging from 0 to 8 mg/L. We determined the root activity, rate of O_2^- generation, H_2O_2 and malondialdehyde (MDA) contents as well as activities of superoxide dismutase (SOD), peroxidase (POD), catalase (CAT), H^+-ATPase and Ca^{2+}-ATPase of Chinese kale roots exposed to five different Cd concentrations for 10 days.

The root activity decreased with increasing Cd concentration, which resulted in a significant increase in O_2^- and H_2O_2 concentrations and MDA content, compared with the control (CK). Increasing Cd concentration enhanced activities of SOD, POD, and CAT ($P < 0.05$), which indicated that the Chinese kale plants were stressed by Cd. No significant difference in H_2O_2 content was observed among the CK, 1.0 and 2.0 mg/LCd treatments, while a similar trend was observed in rate of O_2^- generation between the CK and 1.0 mg/L Cd treatment. The activities of H^+-ATPase and Ca^{2+}-ATPase first increased and then decreased with the increase in Cd concentration. In addition, the activities of H^+-ATPase and Ca^{2+}-ATPase showed no obvious change ($P > 0.05$) in response to 1.0 mg/L Cd, but significantly decreased with stress induced by 2.0, 4.0 and 8.0 mg/L Cd ($P < 0.05$). A negative correlation existed between the level of membrane lipids and the two enzymes. We concluded that there was no noticeable change under a low Cd concentration of ATPase activity in the plasma membrane of Chinese kale roots, whereas under relatively high Cd stress activity dropped markedly and root growth was suppressed.

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