New insights into the Adaptation of Ecosystems to Toxic Substances

American scientists have observed that some plants are able to accumulate the toxic element selenium at unusually high levels. They have shown that this accumulation ability, and the associated selenium tolerance, can enable selenium to move up the food chain. The results provide new insights into biological adaptation to toxic substances that may have interesting agricultural and medical applications.

The biological toxicity of selenium (Se) was recognised in the 1930s when some livestock diseases and deaths were proven to be the result of chronic Se poisoning. These diseases occurred in areas where large amounts of selenium were available in the soil for uptake by plants, which were then ingested by animals. During the last decades, researchers have shown that selenium is an essential element at trace levels, but they have proven that, at high levels, selenium is toxic for organisms and causes disease and poisoning.

Nevertheless, some plants are able to accumulate this element from the soil at very high levels, typically two orders of magnitude higher than other species growing in the same habitat. Tolerance to selenium is enabled through a conversion of this element into a non-toxic form. Experts usually hypothesise that this intriguing high accumulation phenomenon serves as a defence function, repelling herbivores through dissuasion and toxicity.

In a new study, American researchers have proven that a hyper-accumulation of selenium plays a defensive role. They have also discovered a new Diamondback moth variety able to thrive on Se accumulator plants; whereas they observed that other varieties of this invasive pest feed and lay their eggs only on plants that have not accumulated selenium. They conclude that the selenium hyper-accumulation ability of some plants protects them from predators by dissuading selenium-sensitive pests from feeding.

The authors further studied the Se-tolerant Diamondback moth and one of its parasites. Through a chemical analysis, they showed that both the newly discovered moth variety and its parasite accumulate selenium at unusually high levels and in the same non-toxic form as the Se accumulator plants. The second striking conclusion of this study is that selenium-tolerance and accumulation enable it to move up the food chain. The scientists argue that these two characteristics could serve as a pathway for selenium entry into certain ecosystems.

In a broader context, the researchers highlight that the defensive role of selenium accumulation could be introduced either naturally or by genetic modification into crops, thus protecting the crops from herbivores, which in turn could result in increased productivity. In addition, the authors argue that the Se-tolerant moth could be used to control hyper-accumulator plants in areas where they are ingested by livestock and may cause poisoning. Furthermore, the accumulation of selenium could help depollution of both Se-polluted soil and water. Finally, these Se-accumulator organisms could also help collecting a non-toxic form of this substance, which is said to be anti-carcinogenic and anti-mutagenic.

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Theme(s): Biotechnology, biodiversity, agriculture.

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To cite this article/service: "Science for Environment policy": European Commission DG Environment News Alert Service, edited by BIO Intelligence Service.