Serpentine plants survive harsh soils thanks to borrowed genes

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An international team of scientists, which included Dr. Kirsten Bomblies and Dr. Levi Yant from the John Innes Centre, has taken advantage of advances in genomics to work out which genes give serpentine plants their incredible tolerance. Credit: The John Innes Centre

Scientists from the John Innes Centre have analysed the genomes of plants that grow in harsh, serpentine soils to find out how they survive in such conditions. It appears that they have used two strategies: adapting to their environment through natural selection that acted on genetic variants which arose locally, as well as by borrowing useful variants from a related plant growing nearby.

If a plant could choose where it wanted to grow, it probably wouldn't choose serpentine soil.

Derived from serpentinite rocks, serpentine soil is dry, low in nutrients, and typically contains metals like nickel and chromium in concentrations that would be toxic to most species.

Nevertheless, a few hardy plants have put down roots in these 'serpentine barrens' - but just what it is that makes these plants so well adapted to such an extreme environment?

An international team of scientists, which included Dr Kirsten Bomblies and Dr Levi Yant from the John Innes Centre, has taken advantage of advances in genomics to work out which genes give serpentine plants their incredible tolerance.

"Improved technology and a much reduced cost means we can now conduct more complex genomic analysis than ever before," said Dr Yant, a research group leader at the John Innes Centre and corresponding author of a new paper published in *PNAS*. "We wanted to compare plants of the same species from serpentine and non-serpentine populations to try and find the differences between them at the genomic level."

Seeds of a flowering plant called *Arabidopsis arenosa* were collected from all over Europe. "We have been working on adaptation in *A. arenosa* for some years, but then we found a botanical survey published back in 1955, which recorded a population growing in a serpentine barren in Austria, which is an extreme habitat even for this species," explains Dr Bomblies. "It was still growing there when we visited the same site in 2010, so we collected its seeds, as well as those from about 30 non-serpentine populations, and grew them all in common gardens back at the lab to compare them."

This study, published today in the journal *Proceedings of the National Academy of Sciences* further affirms that *A. arenosa* is an excellent model for studying the genetic basis of adaptation. It is closely related to *A. thaliana* and *A. lyrata* - two well-studied species used as model organisms for plant research, which helps tremendously in the assessment of gene function.

Tissues from plants grown from the collected seeds were used for genomic analysis. As expected, the researchers found that the serpentine population of *A. arenosa* in particular possessed gene variants that may help them cope with challenges such as drought and low soil nutrient status.

"Knowing which genes help serpentine *A. arenosa* to thrive in poor soils should be useful for crop breeders, who may be able to use this knowledge to rationally develop stress resilient crop varieties," said Dr Yant.

So how did serpentine-tolerant *A. arenosa* get the genetic changes that have helped it to colonise serpentine barrens?

"We think some of *A. arenosa*'s adaptations evolved completely independently through natural selection, but interestingly, we also found some distinctly *A. lyrata* gene variants in the genome of the serpentine-tolerant *A. arenosa*, but not the other *A. arenosa* populations," said Dr Yant.

"This suggests that serpentine *A. arenosa* has 'borrowed' some advantageous migrant genes from populations of its cousin growing nearby."

He concludes: "The findings of this study advance our knowledge of the complex ways in which plants adapt to - and even thrive - in harsh conditions, and that knowledge is very important as we seek to mitigate the effects of degrading agricultural lands and a rapidly changing climate."

More information: Borrowed alleles and convergence: Serpentine adaptation in the face of interspecies gene flow, *PNAS*, www.pnas.org/cgi/doi/10.1073/pnas.1600405113

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