



HELPING CROP PLANTS ADAPT TO HARSHER ENVIRONMENTS

Hanh Vo^{1*}, Caitlin Dudley², Vanessa Tonet³, Jazmine Humphreys¹ and Eloise Foo¹

¹School of Natural Sciences, University of Tasmania, Hobart, TAS, Australia

²Queensland Alliance for Agriculture and Food Innovation (QAAFI), University of Queensland, St Lucia, QLD, Australia

³School of Forestry and Environmental Studies, Yale University, New Haven, CT, United States

YOUNG REVIEWERS:



VICTORIA

AGE: 10



ZUOTONG

AGE: 12

The global population is growing quickly, and that means we need to find ways to produce more food without causing excessive harm to the planet. On top of this, climate change is making it harder for some plants to survive. Most of the food we eat comes from just a few types of plants, and these are becoming more sensitive to changes in the weather. This can lead to smaller harvests and less food for everyone. To fix this, scientists are looking at the wide variety of plants that grow naturally around us. These plants have learned to survive in different environments, and we can learn from them. Our goal is to understand how plant diversity works and how it's controlled. In this project, we will introduce you to some of the scientists working on this challenge—and maybe one day, you could be one of them too!

SUSTAINABLE

Available for continuous use without depleting the resource or causing environmental damage.

GENETIC DIVERSITY

Differences in traits among populations of the same species.

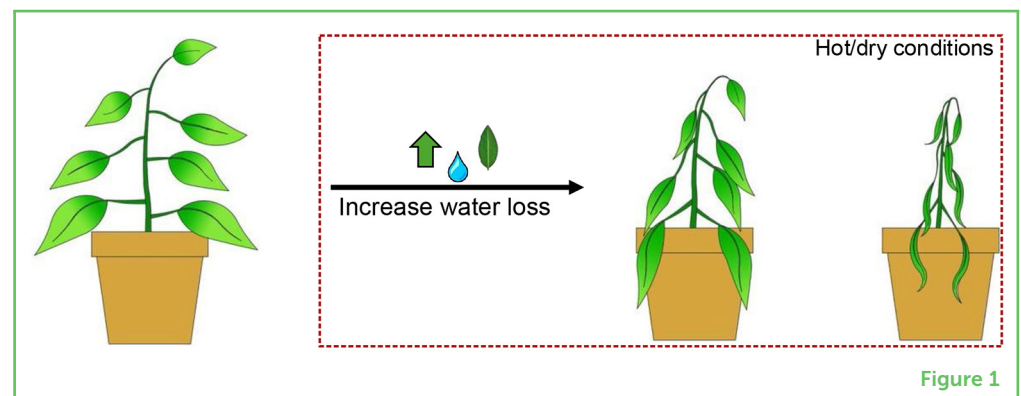
Figure 1

Plants in harsh, dry conditions experience increased water loss through their leaves, leading to wilting and, in extreme conditions, death. As plants cannot move to places with better conditions like animals can, plants must have better strategies to survive in their environments and avoid losing too much water. One way is to increase their genetic diversity (Figure adapted from Ref. [4]).

THE CURRENT SITUATION

The world's population is increasing, and it now stands at more than 8 billion people. Scientists are facing an important mission: we must find **sustainable** ways to produce enough food to feed this growing population [1, 2]. Advances in farming in the early 20th century enabled us to grow more food, but these traditional farming techniques can damage the environment and human health, such as by polluting water sources due to **excessive fertilizer** use.

Even more challenging, we must continue to produce more food despite the effects of climate change [1–3]. One solution could be increasing plants' **genetic diversity**. Two-thirds of the crops that we eat come from three species: corn, wheat, and rice. Over thousands of years, these plants have been bred to thrive in stable environments with lots of water. By breeding these plants to be successful food sources, we have lost the genetic diversity needed for plants to adapt to new environments. This means these crops are likely to be very sensitive to climate change, especially drier conditions (Figure 1). We need to reintroduce diversity back to our crops and increase the number of types of plants we eat.



The diversity and distribution of plant species is often based on climate [5]. Each plant species is adapted to the climate where the plants can survive and reproduce. Some plants prefer the desert, and some prefer tropical rainforests. We can learn how plants grow in extreme, diverse environments and translate that knowledge to crops that are not yet suited to growing in those adverse conditions.

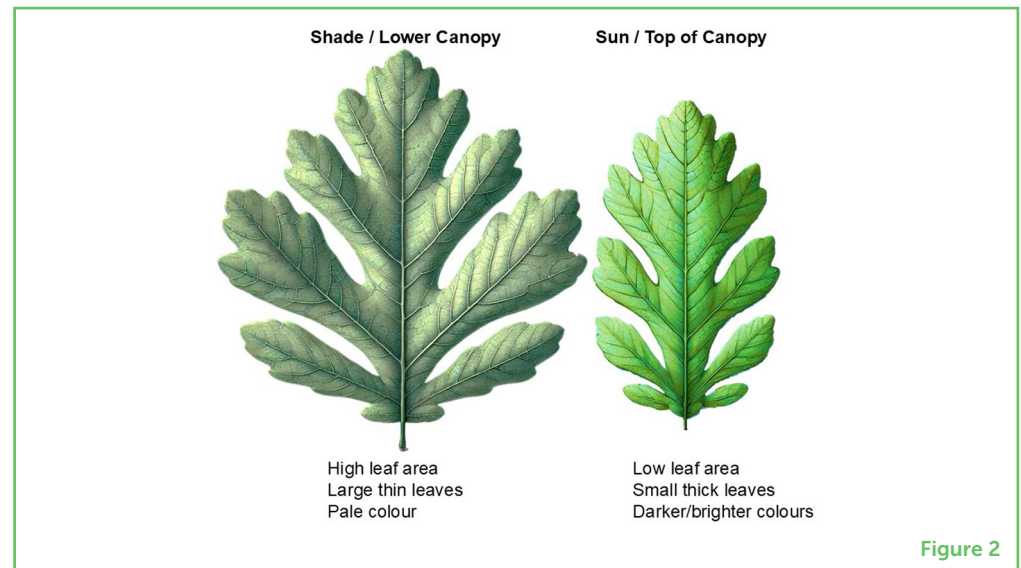
PLANT DIVERSITY IS ALL AROUND US

Look outside your window, what do you see? Maybe a tall tree surrounded by the greenest grass you have ever seen? Or rows of vegetables that you and your family grow by yourself, with colorful flowers and fruits that you will enjoy one day? All the plants we see now, from the tiny mosses to the tallest, largest, **oldest tree**, have been evolving and successfully adapting to changing conditions since

they first appeared on Earth—so they are finely tuned to survive. For instance, have you ever noticed that leaves that grow in the shade are usually bigger than those growing in the sun (Figure 2)?

Figure 2

Leaves of the same species that grow in shade vs. sun show vastly different characteristics. Leaves in shade have higher leaf area and size, but the leaves are thinner and paler green. Leaves growing in sunny areas have less leaf area and smaller but thicker leaves, and they have a brighter green color.



ADAPTATION

Genetic changes in populations (multiple plants) to environmental factors over a long period of time, like several generations.

ACCLIMATION

Changes in individual plants, to minimize the effects of stresses and help them survive. Usually, these changes are short term and reversible.

PLANT ADAPTATION AND ACCLIMATION

Are leaves growing in the sun vs. the shade different because the species has changed in that environment successfully (**adaptation**) or because of one plant changing the leaf to fit with the conditions (**acclimation**)? These two concepts are related but not quite the same (Figure 3). The most important difference is the time scale—how long has this plant/group of plants been in this environment. If it is recent, then it is acclimation, in order to deal with new challenges. If plants have been established here for a long time, then that means they have been adapted.

Many plant species have high genetic diversity and thus have more flexibility. For example, if you ever have a chance to look at cactus roots, you will see a deep, extensive network with many fine roots (called root hairs), developed specifically to search for water. The number of root hairs can rapidly change, depending on water availability. In contrast, rice have small, shallow, weak root system that are not strong enough to withstand harsh environment. This characteristic will not change no matter if you grow rice in a rice paddy or in the desert.

We do not eat cacti much (ouch!), but maybe we can use the secrets of the cactus to help rice thrive in a changing environment. For example, we could use what we know about cactus root to improve rice roots. Firstly, we need to identify genes that are important for root development. Then, we can modify those genes in rice accordingly, so that rice roots can be more similar to cactus roots. With better

Figure 3

Acclimation is when plants change for a short time to deal with the environment, like when plant leaves droop or bend to deal with drought or high light, to avoid losing more water through their leaves. Changing leaf characteristics based on shade vs. sunlight is also an example of acclimation. When the environment stays dry for a long time, plants will fundamentally change over several generations to fit with the new environment, which is called adaptation. For example, cacti have evolved spikes instead of leaves to limit water loss as much as possible. Cacti will not lose its spikes even if you grow it in wetter conditions.

TRAIT

A characteristic that describes how plants function and interact with their environments.

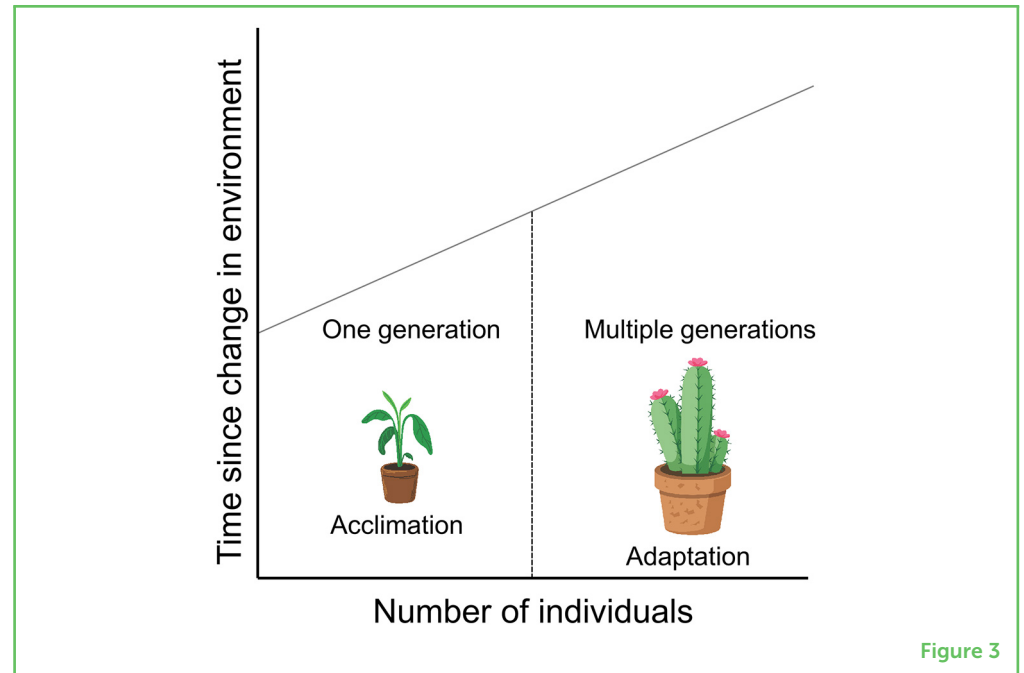


Figure 3

roots, rice can withstand harsher environment, and can search for water better (decrease water usage). It sounds so easy! However, any changes in genes can be unpredictable. Hence, whenever we make any changes, we need to be careful.

SCIENTISTS IN ACTION!

The ways plants might change with the environment can sometimes be hard to predict without extensive studies. Plant scientists are trying to understand natural adaptation so they can learn the best ways to grow the foods we eat as environments change. To understand plant diversity and its applications, we need the specialized skills of several types of scientists. First, physiologists (scientists who study plant organs) observe plants, measure their **traits**, and collect valuable information about how changes in environment can impact plant growth. Then, geneticists (scientists who study genes) often look for the genes responsible for plant traits and study how genetic diversity impacts these traits. Crop scientists take what has been learned to see how this knowledge can be used to future-proof crop species. Our group consists of all these types of scientists, and, although we have different “titles”, our jobs overlap a lot.

PLANT WHISPERERS

Plants cannot communicate the way we do, but we can understand them if we know how to listen. Fortunately, these “plant whisperers” have many techniques and new technologies to help them understand how plants feel. For example, we can put tiny cameras on the leaves

DROUGHT

A long period of time with less/no rain and/or water than usual. This makes the ground, river, and lakes dry up, limiting water available for human, plants and animals.

MODEL PLANTS

A plant species that have been chosen by researchers to study due to their value to humans and/or ease of access.

and take thousands of photos to see how leaves change in different conditions. Why? Vanessa, our favorite plant whisperer, says:

“I am a plant physiologist, meaning that I study how plant organs respond to environmental stresses. Given the rise in temperatures and the decrease in rainfall, I am particularly interested in plant response and adaptation to **drought**. I measure plant traits in the natural environment or in the laboratory, where we simulate drought conditions. This is like a plant going to a doctor for a stress test! Understanding plant limitations and adaptations to stress can help us understand what our forests will look like in the future, and which crops are better prepared for climate change”.

DIAGNOSING PROBLEMS

Once the plants tell us what they are feeling, we cannot just change them. Think about when you go to the doctor: the doctor does not prescribe you any medicines until they identify the problem. They might do some testing to figure out what is going on, because behind every diagnosis is a lot of testing. The same is true for plants. We need to know what genes are important, and sometimes we use **model plants** to understand how a crop might respond. This is when we need the work of geneticists, such as Hanh and Jazmine.

“We are trying to find the plant genes that are important for responding to changes in temperature and humidity. We are mostly interested in the DNA itself, but we also use various techniques to link physical response to genes, so that we know what genes are important in different conditions. This is how plants tell us they are stressed. To do this, we stress the plants by changing their environment. Then we examine the plants’ physical response by measuring the amount of water in the leaves, while collecting samples to study the plants’ gene activity. This way, we can link water content to gene activity, to see how plants deal with drought”.

HELPING PLANTS ADJUST TO CURRENT CONDITIONS

Once we have some ideas of what genes are important, we want to move from studying model plants (which we usually do not eat) to crop plants (which many of us love to eat). This is when we need a crop scientist to predict how changing the genes might change plants’ adaptation using extensive experiments and computer modeling, predicting possible outcome in various environment. We need to know how the plant controls its response, and how plants might change when they face stress, especially when it comes to flowering and seed production. These scientists might change some genes to see if plants can adapt better, like how your doctor might give

you a prescription to help you feel better. Listen to our crop scientist, Caitlin, describe how she does this:

"I am a plant geneticist and I work on crop physiology. I study the internal controls for crop plant flowering behavior as well as how the environment is involved in this regulation. Flowers are one of the most important structures in plants! Not only are they the reproductive organs, but they produce the fruits, vegetables, and grains of many of the foods that we eat. I focus on studying the flowering controls in legumes, which are high-protein, sustainable crops important all over the world. I try to untangle the genes and pathways that result in flowering and hopefully optimize flowering behavior".

WORKING TOGETHER

As you can see, there is a lot we need to do, and all of our overlapping jobs are necessary to do it! It is important to check how plants feel at every stage, just like your doctor might ask you to come back for a follow-up appointment. Although our "patients" cannot talk, we love the challenges that come with studying them. Things are getting more and more severe for Earth's plants, and we need more plant scientists than ever. So, come join us!

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AI TOOL STATEMENT

The author(s) declare that Gen AI was used in the creation of this manuscript. [Figure 2](#) was generated using Canva AI.

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YOUNG REVIEWERS

VICTORIA, AGE: 10

My name is Victoria. I love reading and spending time with my three adorable cats. As a softball pitcher, I enjoy the excitement and teamwork the sport offers. I have been playing the harp since I was 4 years old, and I enjoy playing Minecraft with my friends. Someday, I hope to become a scientist.



ZUOTONG, AGE: 12

Hi! I am Zuotong, a 12-year-old bookworm who loves exploring the world through stories and science. I have read the *Harry Potter* series more than twice—each time feels like stepping back into a magical adventure! When I am not reading, I enjoy playing badminton with my friends and staying active. I am especially curious



about how plants grow, and I love learning new things about nature and the world around me.

AUTHORS



HANH VO

Hanh Vo is a PhD candidate at University of Tasmania (UTAS), Australia. She is studying plants response to rapid changes in humidity, and she characterizes the pathway plants use for combating stress. *hanhminh.vo@utas.edu.au



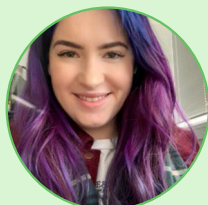
CAITLIN DUDLEY

Caitlin is a Ph.D. student at the Queensland Alliance for Agriculture and Food Innovation, working on understanding the physiological (how different plant organs work) and molecular pathways of plant architecture and flowering behavior in legumes. She is passionate about science, the environment, sustainability, and science communication for future generations.



VANESSA TONET

Vanessa is an enthusiastic tree physiologist with a passion for plant hydraulics! She is currently investigating what kills trees and the link between drought and failure of the leaf water transport system. When she is not studying plants in the lab you can find her outdoors, hiking and rock climbing!



JAZMINE HUMPHREYS

Jaz is a post-doctoral fellow at UTAS who works on understanding how genes are switched on and off in response to different stresses. She combines experiments performed in model species with large-scale experiments in diverse Australian native plant species to pinpoint the genetic basis of adaptation.



ELOISE FOO

Eloise is an professor at UTAS. She is a plant developmental biologist interested in how plants interact with their environments and how this is regulated by plant hormones: small, mobile, potent signals. Eloise also holds an ARC grant that aims to decode the signals important for plant-microbe interactions. She has contributed to the discovery and current understanding of the newest plant hormone group, strigolactones, and has defined novel roles for plant hormones in plants' relationships with beneficial and pathogenic microbes.