Plant Scientist Looks at Roots of Regeneration

New CFI-funded equipment will allow researcher to zero in on plant genes

By Andrew Vowles

Prof. Manish Raizada hopes his plant regeneration work research find its way into a variety of applications.
Photo by Grant Martin

Prof. Manish Raizada, Plant Agriculture, reaches forward and plucks a leaf from the potted plant on his desk. Pointing to the torn end of the leaf, he explains that all he needs is a bit of growth hormone and water to begin growing not just a new leaf but an entire plant.

"That's an incredible process," he says. "It's the equivalent of me cutting off my hand and putting it in water and growing a new person."

Learning more about the mystery of plant regeneration - what Raizada calls a fundamental biological question with practical applications in everything from weed control to forestry to the world's food supply - is the purpose of research that has received almost $125,000 from the Canada Foundation for Innovation's New Opportunities program. With additional funding from the Ontario Innovation Trust and from industry and University contributions, he expects to receive a total of more than $300,000 to buy a sophisticated microscope and camera, as well as a device for detecting and measuring minute amounts of light emitted by specially tagged genes inserted in a common mustard plant. The ultimate goal: zeroing in on the genes that Raizada and other scientists believe allow plants of all stripes to do their regeneration trick, and using that knowledge to improve plant breeding and agricultural practices.

Any gardener who's ever hacked a dandelion out of the front lawn only to see the weed return seemingly stronger than ever can appreciate the Hydra-like power of plants to renew themselves. Scientists believe that a handful of genes produce specific proteins that trigger the process. They also think these same genes govern that process in all plant species, from that aggrieved houseplant on Raizada's desk to the black locust trees shading Reynolds Walk outside his office in the Crop Science Building.

Much of regeneration remains a mystery, including the central question of why plants can do it routinely while most animals - apart from, say, lizards, which lose their tails and grow new ones with impunity - are stuck with the parts they were born with. Raizada thinks the explanation lies in a crucial distinction between plants and animals.

Legs and arms allow us to move and manipulate things in response to environmental changes. But plants cannot simply up and leave when things go wrong in their environment. Their solution to reduced light or some obstruction is to grow a new limb.

Raizada thinks that ability is connected to the question he's investigating: how a severed plant part holds the potential to become a completely new plant. Like undifferentiated stem cells in animals that are able to grow into muscle, bone or brain tissue, he says many plant cells can become a true stem cell again to produce a new root or plant.

Using Arabidopsis, a member of the wild mustard family that he describes as "the fruit fly of the plant world," he hopes to uncover the genes responsible for regeneration and to learn more about the environmental cues that cause those genes to switch on or off. He notes that his work builds on 50 years of research in this area, including major contributions by his colleague Prof. Praveen Saxena.

Much of Raizada's work involves old-fashioned plant-breeding techniques that farmers have used for thousands of years and that Austrian monk Gregor Mendel used when he made his foray into genetics just over a century ago. But not even Mendel would have imagined combining bits of wild mustard with fireflies, using instruments like the equipment on Raizada's shopping list.

Into the plant's genetic material he stitches the gene that makes the luciferase enzyme, responsible for allowing a firefly to light up. Out of tens of thousands of resultant copies of the plants, he expects that in many specimens, that light-up gene will have inserted itself near one of the plant regeneration genes he's interested in.

He plans to expose the plants to various environmental factors, such as changing temperature or salt concentrations, introducing toxic metals or pathogens, and mechanically wounding the tissues like a gardener would. Then he'll determine which genes switch off or on in response by seeing which plants light up.

Besides a microscope and camera, the CFI funding will pay for a device that measures the photons being emitted by the plant. Although the results show up in lurid colour on treated microscope photos in a journal article published last year - the article was based on work Raizada did with corn for his PhD thesis at Stanford University - the "flashes" of light from the firefly gene are far too fleeting and minute to be seen with the naked eye. (He counters a somewhat frivolous aside about the prospect of garden centres rushing to stock glow-in-the-dark plants based on the technology. You'd need a lot more candlepower than is given off in an enzyme-driven reaction to spark up your garden.)

The technique offers molecular biologists like Raizada a quick way to screen plant material for pertinent enzymes and genes. He hopes to isolate the first of the genes within two years and credits the progress his laboratory has made so far to the work of technician Rosalinda Oro and a number of Guelph summer students and undergraduates.

Raizada hopes his plant regeneration work will find its way into a variety of applications:

- enabling Third World farmers to develop new plants from rootstock instead of having to buy hybrid seeds each year;
- improving weed control by preventing regeneration;
- helping breeders from ornamental horticulture to forestry grow plants with desirable traits more quickly and efficiently;
- turning plants into mini-factories for making anything from industrial chemicals to medicines ("I'm hoping plants can become a renewable source for manufacturing," he says); and
- helping farmers develop even more intensive practices to produce more food with fewer resources such as water and land. ("In the next 20 or 30 years, we need to produce more food than we have in the entire history of humanity.")

It wasn't until Raizada's own undergraduate days at the University of Western Ontario that he decided to study plants. He had still been considering medicine when he took two courses in plant and animal development in the same year. "I had always thought plants were very simple compared with animals."

Plant regeneration fascinated him. More than that, he realized that applying the principles of plant growth to growing food more cheaply and readily would affect far more lives than any doctor could hope to. That realization meshed with a passion he had developed while in high school in Brampton.

Horrified by the TV images of famine-stricken Ethiopians during the early 1980s - and angered at apparent apathy among his high school peers - he ran for school council president and led fundraising efforts for UNICEF.

Another eye-opener came during a visit to northern India while he was in university. Raizada says he'll never forget the eight-year-old girl at a market beaming over the half-rotted cauliflower she'd managed to scavenge. How could this be happening in the 20th century, he wondered.

That sentiment sustains his research today. "The root reason I'm doing this ultimately is because I want people like that to benefit."