Issues

What use is a PhD in horticulture?

Julian Heyes

Horticultural industries around the world are thriving. Global trade in fresh products from temperate countries is expanding with exciting new cultivars offering improved flavour, texture or appearance. New technologies are allowing increased quantities of highly perishable tropical products to be sold far from where they are grown. Advanced horticultural industries are highly sophisticated operations that may use satellite data to guide their tractors, remote sensing to target inputs, biocontrol to manage pests, mechanised harvesting, on-line grading, sophisticated packaging, track-and-trace technologies and consumer science to understand which quality attributes are most desirable. At the other end of the scale, small farmers in developing economies with adequate access to water are finding that devoting at least part of their land to horticulture can increase both their total income, and the frequency of their income, as long as they know who wants to buy their products and how to reach that market. Underlying these advances is an enormous wealth of horticultural knowledge, which is expanding each year and much of which is emerging from the efforts of PhD students around the world.

Some of these students may expect their PhD to be a ticket to employment as a researcher or University academic. But every year some PhD graduates find employment with private sector horticultural employers: and it is my contention that this proportion needs to grow.

But what can an employer expect from a horticultural PhD graduate? Firstly, I need to acknowledge that there are very many kinds of 'horticultural' PhD research areas, from social science analysis of a supply chain problem to mathematical modelling of air flow during pre-cooling. As a horticultural supervisor, I love being involved in peripheral projects, for example where fruit pomace is screened for efficacy against breast cancer. Clearly, not all graduates who have had contact with 'horticulture' will have extensive horticultural knowledge, but this should be evident from the topic of their thesis.

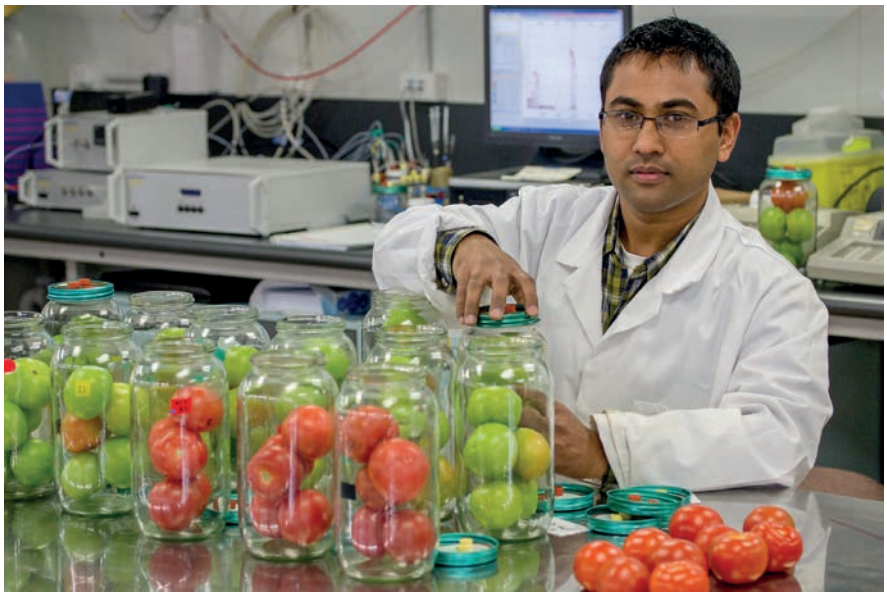
Nevertheless, there are some characteristics and attributes that I would expect a candidate to develop during any PhD. They come about because of the transformative power of the lengthy PhD process. The word 'education' literally means 'drawing out'. 'A mind is not a vessel to be filled, but a fire to be ignited' (Plutarch, ca. 46-125 CE). As we encourage our students to exercise their powers of reflection, we are helping to shape the unique blend of critical faculties they offer to the world.

The process of training the new student's mind begins as soon as they arrive to begin their PhD. Without exception they come to us as intelligent and self-motivated individuals. But once the discipline of intense concentration begins, we see how those students respond under the most severe academic pressure they have ever experienced. They learn the excitement of designing experiments and the necessary tedium of carrying them out. They learn to cope with the grim reality of missing data points, equipment failure, and unpredicted weather events. They may become ground down by the long hard slog of data processing and interpretation, constantly re-assessing their own conclusions in the light of new data or newly published research. And they have to learn to write in a way that is clear and precise and conveys meaning, not just facts.

And out of this intensely personal struggle we look for a number of characteristics to emerge. The first is the ability to stick at an enormous task and not give up. 'Giving up' (or 'reclaiming your life', as some may describe it) becomes very tempting for some students when facing endless rounds of highly critical feedback as they reach the final stages of assembling their thesis.

In addition, we expect our students to acquire a measure of healthy scientific scepticism; just because these data fit my hypothesis does not 'prove' anything. What else

› Janyawat Vuthijumnonk. Her PhD was supervised by a team led by Julian and she graduated with a PhD from Massey University in 2016 for her work on blueberries and the risk of breast cancer.



› Dr. Palash Biswas, whose PhD was on the use of intermittent warming to reduce chilling injury in tomatoes.

› Dr. Abdul Jabbar, whose PhD was on predicting storage outturn for kiwifruit.

› A group of students visiting a kiwifruit export facility.

might explain the data? How do I handle biological diversity; is a non-significant trend telling me I should repeat the experiment with greater replication, or telling me there is no real effect? By the time they finish their degree, PhD students are forced to doubt themselves, their work, their supervisors and everything they have ever read.

What emerges from this refining fire is deep, intricate and subtle knowledge in one specific area; this is an absolute requirement of a PhD. The candidate must show they are familiar with all that has been published in their chosen area, and what is novel about their own work. PhD graduates in experimental sciences will develop technical skills in precise data capture and manipulation. They know how to record, analyse and present information and the limits of what their findings imply. They should have strong abilities in communicating accurately, both verbally and in writing, according to the needs of different audiences. We love to see them attending ISHS symposia to present their work and handle curly questions from the floor.

One of the particular attributes we look for as a student progresses through their PhD is insight. This is the ability to go beyond what they have found and speculate on what might be (and if possible, design a way to investigate that new idea). We want to develop students who are able to look at apparently unrelated pieces of information and let their mind roam into the unknown; is it possible that these bits of information could be interpreted in a new way? This is one of the most valuable skills to emerge from a PhD. It is not always well learnt by our students; and is practically impossible to teach. Educational principles would suggest that we need to 'scaffold' our student's learning; providing small steps that are teachable so they can progress to a more complex integrated task. For example, from very early in each student's PhD journey, we may ask them to produce graphs with a few underlying bullet points for their supervisory meetings. Those bullets need to tell us what they think the data say; what they might mean; and what new questions spring to mind from what they now believe. Until we ask them to do this, it is easy to fall into the trap of assuming they can spot underlying patterns or inconsistencies; it is our duty to help them learn to do this for themselves.

Some examples might help make my meaning clear. A graph of data from an experiment may indicate that treatment A is better than treatment B in some way. The bullets need to confirm that this difference is statistically valid, i.e. it is unlikely to have occurred by chance. But the students have to show they are thinking about 'meaning', not just numbers. They may have just shown that disease incidence is significantly reduced by a treatment, and we can share their satisfaction at this evidence of an effect. But if the observed difference is between 80 and 50% incidence, a grower would probably still not have a business! Or, perhaps, a treatment leads to increased productivity of a conventional greenhouse crop leading to an extra 'x' kg of product in first grade per annum. That is a good result, but we want the student's mind instantly to be roaming around; what are the extra labour or agrichemical inputs required, is the market for that product saturated so increased production may lead to a price collapse, could this result apply to a higher-value alternate crop?

As they practise this approach, we usually see students becoming more skilled in describing what they have achieved, but we do not always see them developing insight. In desperation, I have been known to prescribe a course of cryptic crosswords, honing their skills with half-implied associations of ideas that need to be decoded.

All of the above skills should give rise to graduates who are highly desirable employees in many different industries. People who think for themselves, don't accept the obvious, and care about details, are highly valuable.

For academics supervising horticultural PhDs, I contend that our students should acquire a degree of broad horticultural industry awareness, well beyond the specific topic of their thesis, so they understand the con-

› A group of students and supervisors from the Centre for Postharvest and Refrigeration Research at Massey University.

text in which their work sits. As part of their formation, as supervisors, we have a duty of ensuring they are aware of domestic and global trends in their sector: why do some horticultural sectors flourish and others languish? Field trips to horticultural businesses are a useful way of introducing our students to the grim reality of an industry dependent on the vagaries of weather, of labour supply, and of market forces. Exposure to seminars outside their own research area is another essential component of PhD preparation; how do other disciplines tackle problems that my skills do not equip me for? Taking on supervisory or undergraduate teaching opportunities provides a different learning experience for a PhD candidate. And informal discussions about the business of horticulture, from production to global trade, should sharpen their ability to identify 'disruptive' tools or technologies that may spark a new period of growth.

For PhD candidates, I would argue that any horticultural PhD graduate needs to have a clear understanding of the difference between scientific evidence and business impact. They need to be aware of the multiplicity of real-world constraints (such as technology, labour, climate, land quality, supply chain factors, market attributes) that may prevent careful scientific findings from ever having an impact on the profitability of a business. Another attribute of a horticultural doctoral graduate working in any part of the horticulture industry should be relentless curiosity: a desire to integrate what they see and hear into a 'mental model' of the business. Anticipating climatic trends or the trade implications of troubling international politics should be within the scope of a horticultural graduate. And certainly understanding that market demands vary dramatically between people groups is vital.

Our graduates should naturally consider a problem from a wide range of angles and from different people's points of view. They should not assume the problem someone tells them about is actually the problem they need to focus on, if they want to improve the overall operation of a process. Employers of these graduates should find that they bring a willingness to challenge dogma, an insistence on evidence-based decision making, and a love of detail that does not cloud their ability to see the big picture.

For fresh product industries involved in global trade, I believe you need to hire an increasing number of students with masters and PhD degrees. You should expect to find people capable of deep thinking, but with a practical mindset. If we have done our academic job properly, they should be fast at working out who needs to know what information, by when, and what it will take to generate that information. They should be skilled at critical assessment of what is already known, and able to tell the difference between anecdote and current scientific knowledge. A skill they may still need to learn on the job is how to give a 'good enough' answer; not necessarily the 'best' answer. When confronted with a problem, a PhD graduate is inclined to want to gather as much potentially relevant information as possible and to be very wary of leaping to conclusions. This can be frustrating for a business person requiring a good answer in a short time. Good managers will recognise this sense of conflict experienced by a new doctoral graduate and try to give them some leeway to probe more deeply into underlying causes or researching solutions that may have been found in a related industry elsewhere; but making it clear when the decision just requires a 'good enough' answer.

I will have missed many issues in this brief consideration of the value of a PhD in horticulture and welcome feedback, particularly from industry employers of our graduates, telling us what we are doing well and what needs to improve. Tweets to @ISHS_CMFV would be welcomed...

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› About the author

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