BY PETER KONJOIAN AND JONATHAN KARALL

Research in the Exciting Sector of Controlled Environment Agriculture

Peter Konjoian is president of Konjoian's Horticulture Education Services Inc. His career spans four decades as a commercial grower, researcher and consultant. Jonathan Karall is a Ph.D. candidate at Cornell University studying controlled environment agriculture. Konjoian can be reached at peterkfes@comcast.net.

Today's guest is Jonathan Karall. Jonathan received his bachelor's degree in plant sciences from the California State Polytechnic University of Pomona in 2014 with a focus in agronomic principles and practices for field-crop production. During his education he spent four years employed as a farm laborer working on the university's 190-acre farm. Jonathan moved on to Cornell University in 2015 to begin a master's program in horticulture biology focused on controlled environment agriculture (CEA), biological and environmental engineering and economics. He continued his graduate education at Cornell and is currently a fourth-year Ph.D. candidate focusing on the optimization of day-neutral strawberry cultivars in controlled environments.

Peter: Jonathan, thank you for joining us. Let's start by discussing your career plan. As you complete your doctoral program, are you leaning toward an academic or industry position?

Jonathan: Thank you for the introduction, Peter. It's my pleasure to participate in this doctoral duets with you. At the moment, I'm not leaning one way or the other. Although I have several preconceived notions about my projected career path, I have not committed to one track at this time. I think that the biggest reason for that is the flexibility that comes with keeping my options open. However, I truly enjoy the process of not only research but the education of individuals with an underlying interest in the agricultural sector.

Peter: Your answer is refreshing, Jonathan. I like hearing that you feel confident in making industry contributions from either sector — academic or private. As one who's done both, it pleases me to know you are ready, eager and able to operate from either platform.

Jonathan: That's a great thing to hear, Peter. I believe that far too often we fear that choosing one path over another will inevitably close the door on the path not chosen. Hearing that you have successfully explored both paths is reassuring. I believe that my ideal career path would afford me the opportunity to pursue both passions, research and teaching.

From what I have seen, this ideal of mine exists in both the public and private sectors. Furthermore, I find a great deal of self-fulfillment in the act of working with marginalized communities pertaining to agriculture and the application of CEA irrespective of technological scale. The way I see it, all organizations would benefit from some form of community outreach and as such I would love to see the leadership of that as part of my title.

Peter: You hit the nail on the head with that comment. Some 20 years ago, we repeatedly asked the question: How do we educate urbanites about the value of agriculture? How do we engage them in the discussion of how we feed ourselves? And how can we learn what the perceived value of agriculture is to those living in urban environments?

Back then, who would have thought that today, the descriptor urban dessert would exist? Perhaps it's at last being embraced that we're all in this together, there's only one planet to steward together, and it absolutely takes a village. I applaud your philosophy and am confident you will find a path that allows you to practice your passions. With that in mind tell us about your Ph.D. research, I understand you focused on greenhouse strawberry production?

Jonathan: I did. Upon the completion of my M.S. research where I worked with

microgreens and baby leaf greens, I was afforded the opportunity to diversify beyond the leafy green space for my Ph.D. I ultimately landed on CEA strawberries due to the relatively little information that existed pertaining to their cultivation in the U.S. agricultural sector.

It is quite humorous as I quickly found myself cursing my decision to diversify for exactly those reasons. In those early days, I was just trying to figure out how to effectively grow the crop let alone the consideration of accumulating meaningful data. It took some time, but I eventually managed to gain a handle on the logistical challenges of the crop and my research really took off from there.

Peter: It sounds like you experienced a progression I use regarding learning how to grow a new crop. My advice to fellow growers is to embrace a three-year or three-crop cycle learning curve. Year/cycle one is flying by the seat of one's pants, taking someone else's schedule and recommendations and jumping in. Year/cycle two is where one takes ownership of the crop, tweaking schedules and production practices in order to advance knowledge and confidence. Attention to detail is key and this second cycle often results in optimal results.

Finally, assuming year two was successful, I believe it's critical to repeat the success in the third year/cycle to avoid complacency. Too many growers and researchers learn this lesson the hard way; as soon as we get overconfident about mastering a crop a great big backward step suddenly erases hard earned progress.

My point is that what you experienced is common. In both the academic and private sectors, learning how to grow new crops is challenging and requires commitment and discipline. Sometimes a graduate student faces a double challenge by not only conducting research for the first time but also growing a crop for the first time. If the crop isn't grown properly how might that affect the results and outcome of the experiment? Please continue about your research.

Jonathan: The overarching goal of the project was identifying efficient means of energy use for producing strawberries in the face of increasing demand for local and year-round availability in regions where production is historically seasonal. This is important because, in conjunction, these two traits of interest can often conflict with environmental sustainability, which is critical as we look to the future.

The Greenhouse Lighting and Systems Engineering (GLASE) grant that my work is a part of focuses on just that. Over the past four years, I have identified commonly available genetics that are better suited to CEA production systems and quantified the effects of various supplemental lighting systems' interaction with seasonality. I also developed light and CO_2 crop growth models for improved light use efficiency and measured the effects of supplemental far-red light on yields and carbohydrate partitioning.

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One of the fundamental differences between my M.S. and Ph.D. work has been the need for interdisciplinary collaboration, especially with those in the engineering and computer science fields. This has given me an appreciation for the time and collaboration that is essential to the seamless application of projects where multiple parties are involved. These past four years have been an eye-opening and rewarding experience that I am excited to take into the next chapter of my career.

Peter: Learning about interdisciplinary collaboration will be invaluable. All of us benefit from this; as stated above, it's going to take a village for us to address global food production. Let's stretch the collaboration concept; at this point in your career, how do you view the commercial grower sector? Have you been able to meet growers? Are you more tuned to greenhouse, indoor CEA, or traditional field production systems?

Jonathan: I would start by saying that I largely consider the CEA strawberry industry to be in its early growth phase, not only from a global perspective, but especially in the U.S. The way I see it is that there is more potential in this sector than I can shake a stick at. That being said, I also see a fair degree of risk in the overzealous expansion into the industry.

I have had the great pleasure of traveling across the globe to further understand the potential of agricultural markets and strawberries in particular. The average U.S. consumer's perception of the value of fruit crops is uniquely different from many countries where CEA strawberry production is a more mature industry. Although it is quite clear to many that U.S. consumer satisfaction in strawberry quality has been on the decline, it is my opinion that the willingness to pay lags behind. While the psychology of this behavior is outside of my expertise, I believe that it plays a vital role in the future potential of the industry.

For now, this leaves field producers as king but in time, I believe that a shift is inevitable.

While I have a strong appreciation for the indoor vertical space, there are far too many advantages afforded by a quality greenhouse structure to believe that growing systems reliant on energy intensive sole source lighting will be the segment leader with respect to production scale.

That being said, there are a number of implications where indoor vertical space is particularly unique, so its competitiveness should not be discounted. CEA technology combined with the right crop could be unstoppable. I have a few theories about what the right crop is, but that's a discussion for another time.

Peter: Our philosophies align again, Jonathan, in that we don't view the agricultural landscape as a zero-sum game where one system wins and commands all of the production space. We both feel that market factors and economics will support flexibility in future production. Another way of describing this is that a one size (production strategy) fits all approach won't be enough to feed the planet. Thank you for your insight, and best of luck in whichever direction your next position takes you. gpn