

iLLUminate Blog Transcript: Phil Coles and Todd Watkins on Protecting Mushroom Crops from Pests and Diseases

Recorded January 19, 2024. Listen to it [here](#).

- ANNOUNCER: 00:02 This podcast is brought to you by iLLUminate, the Lehigh Business blog. To learn more, please visit us at business.lehigh.edu/news.
- JACK CROFT: 00:14 Welcome. I'm Jack Croft, host of the iLLUminate podcast for Lehigh University's College of Business. Today is January 19th, 2024. And I'm talking with Phil Coles and Todd Watkins about their roles as economists on an ambitious \$7 million, multi-university and multidisciplinary USDA grant titled, "Focusing on Novel Pest and Disease Management Strategies for U.S. Mushroom Farms." Phil Coles is a teaching associate professor in the decision and data analytics, or DATA, department, who has worked in the mushroom industry for more than 40 years. Todd Watkins is a professor of economics and has served as executive director of the Martindale Center for the Study of Private Enterprise at Lehigh since 2015. Welcome to the iLLUminate podcast, Phil and Todd.
- TODD WATKINS: 01:09 Thanks, Jack. It's great to be here. Thanks for having us.
- CROFT: 01:12 Now, it seems that many, if not most, government grants have involved researchers at one institution looking at a targeted outcome that it's looking to achieve. So let's start by talking about the broad scope of the USDA grant that you're both part of. What is the problem this grant seeks to solve? And how significant an impact do pests and diseases have on mushroom crops each year?
- PHIL COLES: 01:40 Well, pests are a big part of growing mushrooms, right? There's all these bugs that are out there that are trying to eat our mushrooms before we're able to get them to market. So typically, probably across the industry, 10 to 15% crop loss is typical. And it can be as high as 100%. It depends on what the disease is, what the season is. It's a lot more difficult in the summer than it is in the winter months because the mushrooms are grown in climate-controlled rooms. So if it's the winter season, they can't move from room to room, assuming that they're separated. But in the summer, that's when it starts to build up and going into the fall. And we're dealing with two main arthropod pests. They're both fungus gnats. It's a sciarid fly and a phorid fly. What's interesting, the sciarid flies are a bigger issue in Berks County, Pennsylvania, and the phorid flies are a bigger issue in Chester County, Pennsylvania. That's one of the things that's not understood at all. We'd love to know what it is that's driving the different types of species there. They cause a lot of damage on their own where they'll reduce crop yield. They'll also damage the quality. And I always like to say that people don't really care what food tastes like. They want to make sure that it's pretty. It's like as if we eat with our eyes. If there's blemishes on them, people will not buy them. They become unsalable. They end up in canned product. They won't sell for fresh. But in addition to the problems that those arthropod pests cause on their own, they're also vectors of diseases. So there's a disease called green mold. There's verticillium. There's virus diseases. There's all types of diseases that mushrooms get. And that's why there's so many plant pathologists working on this project. So tremendous, tremendous losses due to these pests.

- CROFT: 03:45 What does mushroom farming mean to the U.S. economy in terms of jobs and money? And how does that compare to the global mushroom industry?
- WATKINS: 03:57 I can take that one, Phil, if you want.
- COLES: 03:59 Yeah.
- WATKINS: 04:00 Globally, I think the mushroom industry is a 50- or 60-billion-dollar industry globally. And I was reading a projection a few weeks ago that the expectation is a \$100 billion industry by 2030. So it's a substantive industry. It's not as large as some of the big cash crops, but it's an important industry globally. The U.S. is a smaller player in that global industry. China is a huge player there. But the U.S. market is about a billion dollars in direct sales of mushrooms. And with all the multipliers of delivery and jobs and suppliers and distribution systems, it's probably \$3 billion impact on the U.S. economy, which is plus or minus tens of thousands of American jobs involved. What's interesting to us is that Pennsylvania is by far the largest supplier of mushrooms in the U.S. So Pennsylvania is more than half, probably two-thirds-ish of the U.S. mushroom production. So it's largely local for us. So Phil and I can interact with most of the major growers right here within an hour or two drive.
- COLES: 05:15 It is the largest cash crop in Pennsylvania.
- CROFT: 05:19 Now, what universities are involved in the grant? And I think that probably reflects some of what you've been talking about in terms of its importance in Pennsylvania.
- WATKINS: 05:29 The grant is housed at Penn State University. Penn State has a fairly large mushroom research group there. And there's some folks from the University of Delaware, University of Florida, and one person from, I think, Cal State, Monterey involved in addition to us. So it's multi-institutional. It's pretty cool.
- CROFT: 05:51 And I think Phil had mentioned some of the disciplines that are involved. But what is kind of the range of disciplines that are represented by the grantees?
- COLES: 06:05 Well, it's mostly plant pathologists. There's actually five plant pathologists that are involved, three computer scientists, two mushroom scientists. And there are also plant pathologists, two entomologists, a plant geneticist, a natural products chemist. And Todd and I are the economists. And then there's one extension educator because part of the grant is to make sure that the word gets out amongst the mushroom farmers what the recommendations are that come out of the grant.
- CROFT: 06:39 So with all of these different disciplines involved and different universities involved, is this grant an example of, perhaps, an opening to expanded research funding opportunities in the academic world?
- WATKINS: 06:58 Yeah, I would agree with that assessment, Jack, that not only this grant, but sort of the general trajectory of many of the federal granting agencies is in this multidisciplinary or cross-disciplinary direction. Phil and I have kicked tires on several ideas just in the last month or two after this grant got awarded about other types of agencies and questions that we might want to tackle. And we've been reaching out to people across Lehigh and elsewhere, thinking about sort of next stages that this could grow. I think the general trend in many of these granting agencies - and I'm working on a separate grant for the NSF, which has a lot of multidisciplinary characteristics to it - are there ways to-- if the laboratory science is successful, how do you facilitate moving that into the marketplace or into the hands of people who will use it? How do

you accelerate that take-up? Are markets going to be ready for it? What are the barriers? What kind of consumer behavior might be involved? What sort of policies might be needed or changes might be needed to make it happen? And you got the business and entrepreneurship problem of, what's the ecosystem to ramp this stuff up and get it to scale and distribute it to whoever is going to use it? Those are all things that require disciplinary thinking way outside of the narrow box of the laboratory science. And so, in part, that's what we're bringing to this mushroom grant, which is, there's great entomology science involved here, but the reality of the business is, is this going to be cost effective? How much should you spend on this? Is that enough? Is this enough? Should you raise the temperature to pasteurize things? Does it really have to be as high as that? Could it be a little bit lower? Could you save a little bit of money? Lots of multidisciplinary questions in there.

CROFT: 09:09

Okay. Now, Phil, we were talking before we started this about kind of the history of industry following this kind of more holistic or multidisciplinary or whatever you want to call it approach to solving problems. And I think that was an interesting kind of background of what's happening in the government and academics now. So could you talk about that a bit?

COLES: 09:45

It's been happening in a lot of different areas. So when I was an undergraduate in the early '80s and just beginning my work in the industry, there was something called integrated pest management that was the up and coming thing where you're integrating everything together. You've got the preventative things. You've got what it is that you're doing for the arthropod pests, for the diseases. And you're bringing them all together so that they're working together. And that's the idea behind IPM, or integrated pest management. And really, if you're a farmer, and you're not doing integrated pest management, you're probably not farming anymore. It's really become the accepted way of doing that. And the next stage was, well, it should be integrated growing. It shouldn't be just the pest management procedures that you're pulling together. It should be everything that's involved with the growing because even things like if the crop is healthier, no matter what kind of crop it is, not just mushrooms, it's more resistant to arthropod pests, to diseases, whatever it is that you're looking at. But it also comes from a management point of view also when you're looking at it as researchers - and that's what I was alluding to - in business.

COLES: 11:03

So traditionally, what we did, everything was linear. So you would start at the research stage, and then you would maybe look at the economics later on, and you find out the economics didn't work, and you'd have to go all the way back to the beginning. What companies are doing now is bringing multidisciplinary actors together so that it's no longer linear. You're getting input from every single area. And this actually came out of the automotive industry. It started with the Toyota production system, but other companies started getting into that, and famously, the platform systems for Chrysler. That no longer started with marketing and then throwing it over the wall into engineering and throwing it over the wall and into production and so forth. It was multidisciplinary teams together. So if you could see a problem with production or with the costs or whatever, you wouldn't have to go back to the beginning. You could catch things earlier when they're easier to fix. And that's what we're doing from a research standpoint, is have all these different disciplines working together.

- CROFT: 12:10 Yeah. So let's turn now specifically to your role, both of you, as the only two economists on the project. And I'm wondering how unusual it is for a grant like this to include economic feasibility along with laboratory research.
- COLES: 12:28 This is actually a fairly new thing. My undergraduate degree is in entomology, and that's something I like to dabble in is research. And I got several papers that were on pest control. And where I like to look at it is not in the laboratory, but actually in the growing rooms. And when you're looking in the growing rooms, you're seeing actual things that are going on. So this has become much more popular from the grant standpoint, from the scientific standpoint. But this is something that bleeds into what I've been trying to do for a long time. So it's pretty exciting for me to be involved with this.
- WATKINS: 13:17 And circling back, Jack, to your previous question, I think that this is indicative of expanding opportunities for people in the social sciences, the behavioral sciences, business, entrepreneurship, researchers to participate in grant opportunities that we may have not had in previous decades because of the interest in combining forces to tackle really complex problems. I think there's a lot of opportunity for many of our colleagues around Lehigh and elsewhere in disciplines that haven't been as well supported by research grants as the engineering and typical sciences have been.
- CROFT: 14:03 Now, Phil, you've mentioned a couple of times your studying entomology. And if you could give us kind of a brief overview of your 40 years in the mushroom industry, kind of the range of things that you've done, and I think most particularly what that brings to your role in this particular grant.
- COLES: 14:33 Yeah. Well, I guess that's how we got involved in the first place is I already knew these researchers at Penn State for many years, and I worked together with them. And when I was an undergrad-- so I have a degree in entomology, but I always say I really have a degree in mushroom growing. But there is no such thing. You have to have a degree in something. So I took a lot of plant pathology, entomology classes, special courses in learning how to grow mushrooms. I was very, very fortunate to be there when Lee Schisler was at Penn State. And he just was an absolutely unbelievable researcher who also had incredible practical experience, had worked at Moonlight Mushroom for many years and made compost and grew mushrooms. And that's where I really became interested in it. And then I worked two summers at a mushroom farm in Chester County, got some experience there. And that's when the IPM program-- they had a big grant back then in the early '80s. The IPM program was going on. They were learning about the sciarid flies and the phorid flies and how they vector the different diseases.
- COLES: 15:49 And so I came up in that. And then I went to Giorgi Mushroom Company, which since they don't market under that, nobody really knows what that is, but Giorgio Fresh is the largest mushroom producer in the United States. So the Giorgi Mushroom Company is the farm. So that's where I worked for 34, 35 years, something like that. And I also worked very closely with the American Mushroom Institute. So I headed up the IPM committee. We wrote a book on integrated pest management in mushrooms. And as I said, I always enjoyed doing research. So I published some papers about mushroom culture and pest control in the Journal of Economic Entomology, a couple in Plant Disease. And it was my job, but it was my hobby too. So I always enjoy doing

those types of things and writing things for Mushroom News, which is the trade journal.

CROFT: 17:00

We're at the beginning of this grant. The portion, I guess, that includes the work that the two of you will be doing, was a \$302,000 grant to Lehigh Business that is four years. So with the understanding that you haven't really gotten started on the work that you'll be doing, I would be curious, what are some of the factors that you expect you'll be looking at to determine whether possible solutions that they're working on are, in fact, economically feasible?

WATKINS: 17:41

I can take a stab at a first cut there, Phil, and you fill in the details. I'm an outsider in the mushroom industry. It wasn't an industry I knew much about until Phil kind of wrapped me in here. And I've been fire-hose learning a lot. It's an amazingly high-tech sector, but it's also amazingly 19th century, both simultaneously. There's a lot of science behind what's going on in the growing rooms and optimizing growing conditions and pest management and so forth. But it's also highly reliant on people that just have a feel for it. Literally, they stick their hand in the compost and they say, "Oh, it feels about right," or, "No, let's keep working on it." There's an art form, a lot of art form there. And one of the issues that this grant is going to tackle is kind of trying to optimize a lot of the pest management approaches as pest management strategies come out of the laboratory. Are they cost effective? So we're going to try to monitor their effectiveness and then identify cost vectors about, is that the best way to do it, or might there be alternative, more cost-effective ways? One of the big costs is use of energy. They steam these rooms off to get rid of diseases and pests. It costs a lot of money to steam the rooms off. They're also pasteurizing the compost before it goes in. So that energy efficiency, improving the sustainability is one of the big questions we're after.

WATKINS: 19:23

Another issue that is going to be interesting to me at least, and I think Phil as well, because he's in the DATA department, is what you might call smart agriculture. Some of the scientists and computer people involved in this program are going to develop some automated technology for monitoring pests and other issues like moisture, temperature, airflow, that kind of thing. So it's big data. There's a lot of data in this sector, but the data is not really well used to make decisions in kind of optimal ways. And so we're going to, we hope, be able to take some of that data, analyze and optimize kind of along the way to improve decision-making.

COLES: 20:13

Yeah, if I can add to that, Todd brings up a great point about the art. And when I got into it in the late '70s, I mean, it was almost all art. Everybody had a feel. It's how you put the water and the way you flush the rooms, which is when you bring fresh air in to reduce the CO2 that cause the fruiting. And that's what we're trying to do all the time is reduce the art and increase the science. And one of the things we're hoping to do is to coordinate a lot of these things that they're going to be doing in the laboratory with what we're witnessing in the growing rooms. So for example, a couple of the papers that I've done, I almost feel silly presenting them to mushroom growers because they're all things that as mushroom growers, we knew it all the time, except for we couldn't prove it. And sometimes, when you can't prove it, you're actually wrong. So to validate the things that we knew as growers in our gut is very important because we know that we can then move on to other things. But also, some of the things we thought we knew that turned out actually not to be right when we actually looked at the data, we can improve what we're doing so much better and use

analytical tools and standard operating procedures instead of how somebody just happens to feel that day about what they should do with the CO2 or the temperature or the moisture or what have you. The more science we can do, the better off we are.

CROFT: 21:48

Now, is there any lingering tension between the art and the science?

COLES: 21:54

Oh, there always is. This isn't just mushroom growing, right? When I say mushroom grower, fill in whatever job you want to put in there. There's as many ways to grow mushrooms as there are mushroom growers. And every one of them is absolutely right. Just ask them. And so we get into some great debates sometimes. And again, these are people that know what they're doing. They have a lot of pride. And everybody has their own opinion. And that's where, if you look at the data and analyze the stuff, then you can see what really is the best way to do things and go to standard operating procedures, again, rather than just what the feel is because we know that people's opinions are very important. They have great experience. But it can influence things in the wrong way. So it's important to have that experience, but also have data. And you can balance those things very well and come up with much better outcomes.

CROFT: 22:59

I'd like to wrap up, as I usually do, asking if there's anything we haven't talked about that either of you think our listeners should know about the economics of mushroom farming or the grant that you're going to be working on.

WATKINS: 23:14

One of the things that struck me as, again, an outsider to this sector is how quite different the manufacturing, if you will, the production process for mushrooms is globally. The Dutch have a very different system than the Americans have a very different system than the Chinese. And so part of the challenge here is trying to identify a holistic analysis of system-wide things to identify where is it that the real payoffs in spending a lot of money avoiding diseases versus reacting to diseases and so on, and see if we can make sense of why these things are so different globally even.

CROFT: 24:00

Well, I'd like to thank both Todd and Phil for being with us on the iLLUminate podcast today.

WATKINS: 24:06

Well, appreciate you having us. It was fun.

COLES: 24:08

Yeah. Thanks so much, Jack.

CROFT: 24:10

Happy to do it. And we'll check back with you down the line as you actually get into the economic research that you'll be doing with this project.

COLES: 24:19

Looking forward to it.

CROFT: 24:21

Todd Watkins' research and teaching focus on the intersection of innovation, entrepreneurship, public policy, and financial tools for sustainable development. He has published in the journal *Science*, as well as *Research Policy*, *Issues in Science and Technology*, *Technology Review*, *Small Business Economics*, *Industrial Relations*, *Environmental Science and Technology*, and other journals and books. Phil Coles has more than 30 years of industry experience, including serving as vice president of strategic management, project manager, and Kaizen facilitator in charge of the continuous improvement program at a multi-million-dollar produce company. He also runs a consulting firm where he has assisted companies to increase efficiencies through improved plant layouts and balancing of assembly lines, aiding green--fields

startups and company expansions. This podcast is brought to you by iLLUminate, the Lehigh Business blog. To hear more podcasts featuring Lehigh Business thought leaders, please visit us at business.lehigh.edu/news. You'll also find links there to follow us on your favorite social media platforms. I'm Jack Croft, host of the iLLUminate podcast. Thanks for listening.