Frost Protection in High-Density Orchards

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SPEAKERS

Christa Hartsook, Joe Hannan

C Christa Hartsook 00:15

Hello, and welcome to the small farms podcast, a production of the small farms program at Iowa State University Extension and Outreach. Our podcast covers the opportunities and challenges associated with rural life. I'm Christa Hartsook small farms program coordinator, and we hope you enjoy the show. In this episode, I visit with Joe Hannon, commercial horticulture specialist for Iowa State University Extension Outreach, on his research on frost protection of apple trees. Joe, welcome back to the show.

J Joe Hannan 00:47

Hey, Krista. Always good to be here. Thanks for having me.

C Christa Hartsook 00:49

You bet. We love to have you on. Joe, give us a little background on the project itself.

J Joe Hannan 00:55

Sure. So it's springtime, it's 70-75 degrees outside as we sit here and talk about frost, but it is still early April. And this project deals with what happens when we get warm temperatures, we get plants developing the particularly apples, and they start to bloom. And then we get temperatures dipping below freezing. So there's not a lot of different options out there that can manage or prevent that bloom from freezing and dying. So our project is looking at one piece of technology and seeing if we can modify that technology to work as a freeze protection method. And then we figured while we're at it, let's just see if we can make it work automatically for us.

C Christa Hartsook 01:43

Absolutely. So Joe, you know, I know, as you mentioned, it is pretty nice today, but we do have a record of having, you know, freeze type events within Iowa.

J Joe Hannan 01:54

Yeah, I'm not sure exactly what the percentage of having a freeze event between now and May 8 May 10 or so. But it's going to be about 75% chance that temperatures are going to dip back below freezing. And as we look at our forecast coming up later this week, that looks to be true.

C Christa Hartsook 02:15

Absolutely. So Joe, talk to me a little bit about the freeze types themselves, there's a couple different kinds.

J Joe Hannan 02:22

Yeah, so we have really two different types of freeze events. And I say freeze events, we almost often will say frost or frost occurs. Frost is really the formation of ice, what we're really focused on is the temperature and specifically the plant temperature. So that is a freeze. Okay, so there's two different types of freeze events that we're looking at. One is an advection, freeze. And this is where we have cold, dry air, pushing or moving through our environment and pulling that warm air away from the plants and away from the ground. So it's a cold, dry wind. The other type that we have is a radiation freeze. And this is where we have very calm conditions, and cold air settles in down around the ground level, maybe up 50, maybe up 100 feet. And then we have a warm layer of air above that. And so that radiation freeze is very common in those rural areas where we think we've got air movement going on all night long. And then right as sun comes up, the air movement, the wind completely stops, and you get a very cold layer of air settling in and around our plants.

C Christa Hartsook 03:46

Joe, I know we're not at the point yet where we are seeing you know those blossoms or buds on apple trees. But why is this such a concern for apple growers around the state?

J Joe Hannan 03:57

Well, it's, it's a concern because if those apples come out of dormancy, like they should be starting to come out here now. And they bloom and those temperatures drop below freezing, we'll start killing those Apple buds. And the colder we get. So as we drop at 30-31 degrees, we're going to lose a few Apple buds, but we won't lose all of them. But we dropped a little 28 degrees and we're going to lose 90% or better on those Apple buds. And whith Apple's having a set number of flower buds that it puts out in the springtime. If we lose those buds, that's gone and we have no crop that year. Right? So if we have no crop that means then obviously the orchards don't have anything to sell. It means that the trees go into a biennial berry mode where they are alternating by producing high yields and low yields and high yields and low

yields. Excuse me, and that's not very healthy for the tree, sir If we lose our apple crop, that means this year, all that energy will be going into vegetative growth. And so we'll have excessive vegetative vigor out there on those trees, which inhibits light down into the canopy for next year's crop that inhibits air movement for disease control or prevention through next year's crop. Then, of course, if there's no crop out there, the orchard still have to maintain the health of those trees. So they still have investment to going out into the orchard even though there may not be a crop there

C Christa Hartsook 05:33

you bet. So Joe, when we're looking at methods of control, then you know methods to kind of help mitigate some of this damage that can occur from a freeze event, what are we looking at.

J Joe Hannan 05:45

So crystal, when we look at managing or controlling or mitigating a freezing event, we have a couple different options. One is that we can take and put heaters out in the field. And we can put a whole bunch of heaters and spread them all throughout that orchard. But you know, those heaters tend to be an oil based or the combustible product. And you know, that's not environmentally sound. And some places don't allow that anymore. The heaters also have to have a direct line of sight with the tree that they're providing protection to. So if you have a heater on one side of the tree and no heater on the other side, well that backside of the tree is not going to get any any protection. So they're not a perfect solution by any any means they work, it's effective, but it's a lot of work just even just to get them up and manage over the course of the night. So then we have turbines, which are really good under those radiation freezes where they stir that warm air layer up in the 50-100 feet above the ground layer, ground and they mix that warm air with the cold air at ground level. Okay, that provides that protection for the plants. So they are expensive, but they can do anywhere from five to 10 acres reasonably well. So you're looking at a large area of protection with one piece of equipment. Okay, so word of advice from a farmer friend that has one, make sure that tractor is fully filled up going into that frost events so that it doesn't run out of fuel.

C Christa Hartsook 07:27

Sure

J Joe Hannan 07:28

learn that one the hard way. So then that leaves us with another option, we can use row covers over plants. A lot of times you'll see home gardeners will take out blankets and put them over their plants and those blankets row covers will help hold the heat down at ground level. We use it fairly common with vegetables. But when you're trying to work with a trellis tree that is 810 12 feet up on the ground and get row covers up. And over there the trees as about near impossible. We just have way too much wind to actually get the row covers up and over and on the trees. And then you start putting that row cover on trellis posts and conduit that's holding

up holding up these trees, it's going to tear and rip apart you might get one or two uses out of it. So it's seems like it would work but the reality or practicality of it in the field. That it's a disaster again from experience.

C Christa Hartsook 08:29

Sure. So Joe, your research project then on the other hand dealt more with water.

J Joe Hannan 08:35

Yep, so water is an excellent method of providing frost protection or freeze protection to plants. So as water as we pump water onto plants, and if we're under freezing, that water will freeze but as the water freezes on the plant, it gives off energy in the energy that it gives off, some of that goes to the environment, some of it goes to the plant. And as it goes to the there the energy that goes to the plant actually provides that protection to the to the plant or to the flower. The downside with with using water is that it takes a lot of water. You have to keep applying water consistently or constantly until everything has melted off of the flower. So say you applied water and you've got an ice ice build up and temperature has got up above 30 And then and then you shut the water off well as water or as ice and the flowers would melt it would pull energy away from the flowers actually causing more and more damage then had you done nothing. Okay, you have turned on and you have to leave it going for all the way until the ice that's built up on the plant has melted away.

C Christa Hartsook 09:52

That makes sense. So Joe, I know that this has been done typically a lot on some of our larger scale fruit production, you know, when we're looking at strawberries or things like that, have traditional orchards been able to take advantage of this?

J Joe Hannan 10:07

Yeah, so it's a good point, Christa, we've been able to do this on strawberries because we can set up an overhead irrigation system on strawberries, low growing crops very easily. But, you know, previously, we were working with large 15-20, or even full size, standard apple trees and being able to provide water up and over and onto these trees was impossible, we just couldn't do it. As the industry has evolved here across the country, and as Iowa has evolved, the orchards of production orchards have gone to trellised apple trees. And so it's a much smaller, more compact tree much lower to the ground, again, in that eight to 12 foot height range. And so now we can start using these practices that we've used on crops like strawberries, where it's most commonly done on to apples. And so as we look at a couple of our bigger Apple producing states that also have freeze issues during bloom, that's where this project really starts to go and look at what systems they're doing and see if we can approve and adapt on it for for Iowa.

C Christa Hartsook 11:21

Sure. So cost Joe I can imagine that this would be somewhat cost prohibitive for some people

Sure. So cost Joe,I can imagine that this would be somewhat cost prohibitive for some people.

J Joe Hannan 11:28

Yeah, let's just say. So our goal with the project was to scale this so that it works with a common standard Well, with that has an output of like 20 gallons per minute, very common well, that we could find across Iowa and wanted to see if we could retrofit something that would work on those type of well systems. So if you look at what's being used in the other states, they're still pumping out a very large wells or out of surface water sources. And they're using nozzles and fittings that are, you know, might run at 10 to $15 for every unit that you put out there. And if you've got to put out a 1000 fittings and nozzles out in the field, it's going to add up very quickly. So we wanted to see not only could we reduce the water size requirement needs, but also build the system at a fraction of the cost.

C Christa Hartsook 12:32

So Joe, talk to me a little bit then about your design of your research and the study you did.

J Joe Hannan 12:38

Yep, so we went and we looked at all these new types of frame jets and mini sprinklers and fan jet sprinklers that are really just single or very simple plastic spray nozzles. Often times I have just a barbed fitting, so there makes them very cheap, very easy to work with. And put those out into the field and see if we could provide that coverage. And so we look at those frame jets and the mini sprinklers and the fan jets, you know, you go from cost wise from about 15 to 20 cents apiece. And then if you have some fittings and things to connect that into the supply lines, you know, you're looking at about a buck 25 to a buck 50 For every nozzle that's out there in the field. So if you got to put a field out where you put it into 1000 nozzles out at a buck 25 bucks, 50 piece that looks much more friendly than 40 novels out there that are going to run you 10 to $15 apiece.

C Christa Hartsook 13:43

Sure, absolutely. So I'm assuming you know, you replicated this over the course of a couple of years jump.

J Joe Hannan 13:51

Yeah, so goods and bad's about that. We were able to put the design out at a couple different farms to two orchards in eastern Iowa. And the system was out there for the first year. We had everything hooked up where it was just on a barbed fitting hooked up to half inch supply lines going down the top of the orchard trellis, it looked great for the first four weeks of the install. But then as anybody that's worked with drip tubing out in the field, you know that tubing shrinks and expands as we go through summer and winter and fall. And so by spring of year two for the project, let's just say the nozzles were not all straight up and down and required a

lot of work to clean up. But that year two design rather than using the barb fitting to go directly into the supply line. We actually use a couple of fittings to make the nozzle adjustable. So as you know things shrunk or stretched or move around we can go back in and easily correct the adjustment on the on the nozzle so that they're perfectly perpendicular To the ground, and that's where some of those extra fitting costs comes into. So again, it was replicated two locations two years. And the good thing and the bad thing about that is that we didn't have an actual freeze event during bloom. So that's awesome for my farmers, it's really bad for research. Hard to replicate what's going on out there Well, it's, it's hard to say for sure, with 100% definitive that, hey, our system works under pressure. We know our system often works, it puts out the appropriate amount of water volumes onto the plant canopy. But until we have it fully tested under a freeze condition, and I'm not going to go out and say, Oh, you definitely should go install one of these.

C Christa Hartsook 15:47

Right, right. So that brings me to a great point, Joe, talk to me a little bit about some of the best practices you found from your research.

J Joe Hannan 15:55

Well, best practices with a lot of these fittings and nozzles is don't put them too close together. I think our first year out the door, we spaced the nozzles all out at about eight foot. Again, when I it's not my trees and not my crop, I want to make sure I had good coverage, we had very good coverage. So really, you could bump that up anywhere into 14 to 16 foot emitter spacing. Again, follow manufacturers back for those but that should that seems to be pretty common spacing, we liked the frame jets and the mini sprinklers. So mini sprinklers are just sad. It's a little piece of plastic with a little mini sprinkler that spins around and gives you a single stream of water and a 360 degree pattern and just rotates around. The frame jet is six or eight or 12 Little jets of water that come out in a 360 degree pattern. But it's a solid set. So those jets don't move around. And so they worked really well on the field that gave us pretty good coverage. I was very happy with those. In some of our testing inside, we use some of the different fan jets and and I thought there is no way that little fan jets were going to give good coverage. And boy, was I really wrong. I I think they gave excellent coverage as well. So I wouldn't rule those out as an option for your nozzle type.

C Christa Hartsook 17:28

Okay, that's good to know. Yeah. What about the assemblies themselves Joe?

J Joe Hannan 17:34

Well, as I mentioned, from the year one to year two, we hooked everything up either connecting the frame jet or mini sprinkler or the fan jet with the barb directly on to the supply line. That was definitely a do not do that. Instead, what we did is got an adapter that goes from mini sprinkler framed jet into a little adapter that has a pipe thread on the other end. And then we took that pipe thread and adapted that to our supply line. And that allowed us to provide

adjustment control after the fact on those nozzles to make sure that they're perpendicular to the ground. So a little bit of cost there, but not that much. Okay. So I definitely would not stall it directly via the barbed fitting anymore.

C Christa Hartsook 18:21

And overall, Joe, you know, you're in terms of your costs, what were you looking at there to kind of maintain that coverage throughout the orchard?

J Joe Hannan 18:28

Let me see, I go back because I calculated out basically at the at the nozzle. So if you look at our nozzle system, really you're at about a buck 50 per nozzle every 15 foot down the row, and then I just purchased a half inch drip supply line, it was a minimal cost.

C Christa Hartsook 18:54

Okay, okay.

J Joe Hannan 18:56

So I think you could get set up for a couple $100 on an acre pretty easily and then have to add some basic irrigation components like fans and valves and things like that.

C Christa Hartsook 19:09

Sure. And then Joe, you were installing these in kind of a triangular pattern.

J Joe Hannan 19:15

No, we were installing these in a square pattern. So anybody that's designed irrigation knows that there's two patterns, there's a square pattern and there's a triangular pattern. square pattern is when you start at the beginning of the row, let's say you started tree, number one, and then every 15 foot you put a another nozzle in place. And then you go to the next row. You start at tree one and then every 15 foot going down the row so everything is very square shaped. Sure, going through your orchard triangular pattern is starting at tree one, and then go in every 15 foot down the row. And then the next row rather than starting at tree one. You start halfway between tree one and that first nozzle from the other row, okay, and so that gives you a triangular pattern from row to row to row, and gives you a much better coverage pattern that way. Okay, so we set it up in square pattern just for research practices, we wanted it to be everything very uniform. But on a commercial install, I would set it up on a triangular, because you'll get some cross coverage from one row to the next row and that triangular pattern and you'll hit you'll have a little bit of a dry spot from one between the two nozzles. And so having that triangular pattern will kind of pick up that a little bit for you.

C Christa Hartsook 20:36

Okay. What about in terms of overall flow? Then Joe? What did what did you find there from a best practice kind of thing,

J Joe Hannan 20:45

we learned that a 20 gallon per minute, well is only going to give you protection on a high density orchard of you know, about 400 trees or roughly a half acre, we were really hoping that we would be able to find lower flow nozzles out there. But there just isn't anything on the market right now that that seems to do the trick. So everything with the irrigation nozzles is they do a 360 circular pattern. On a high density orchard, you really only have trees for four and a half foot diameter from row, so you get a lot of wasted area going on to onto the grass. And so we're hoping to find nozzles that have more of a rectangular flow pattern that we could put up and really just provide coverage to the actual trees themselves and not be worried about providing coverage to the grass and everything in between those trees. But at this time, we really, there wasn't anything on the market that really kind of fit that need for so there's been no other nozzles like that, that have kind of come and gone. But right now there's nothing that that seems to work.

C Christa Hartsook 21:57

So there's an opportunity for somebody, right future research.

J Joe Hannan 22:00

There's an opportunity from the manufacturers, but I've seen these kind of come and go and they're never really stellar. Yeah, you know, I've, I had one that I kinda liked when I was doing my trials before going out to field size and I really wish I could have gotten enough now. Try it out there because I think we really could have dropped our coverage or increased our coverage from a half acre, maybe up to one or two acres with that type nozzle. But until we get something else, that's just not going to work. So right now, if you want to provide coverage using an overhead frost protection system on orchards, you're either going to have to roll a large well, which is going to be pricey. Yeah, dig a pond, which is going to be pricey. Or you're going to going to need to buy large water storage tanks, which is still pricey and still limited. So we kind of ran the numbers a little bit. And even if you buy a 5000 gallon tank and have that filled up with water, and then start refilling it, as soon as that frost protection system comes on, you're only going to provide frost protection for an acre for a couple hours. Yeah. So it takes a lot of water. It takes a lot of water, because so much water goes to places that we don't want it.

C Christa Hartsook 23:29

Sure. Sure. So I would imagine then, Joe, an excellent strategy would be to really focus on the highest value varieties within your orchard.

J Joe Hannan 23:38

Absolutely. Honey crisp honey crisp and honey crisp

C Christa Hartsook 23:42

Good to know.

J Joe Hannan 23:44

Yeah, put it if you're gonna bill it, put it on those high value crops or that high value. Customer. Yeah, we're whatever one happens to be your big moneymaker.

C Christa Hartsook 23:55

That makes sense. Joe, so what's next? What do you need to do next?

J Joe Hannan 24:00

Well, I have spoken to both orchards that have the system installed. And so while project funding is over, we're going to keep those systems installed and make a few minor tweaks and upgrades and, and corrections to the systems out there this year. And in an effort to have the systems up and going this year, just in case we would get a frost event. Hopefully we don't knock on wood, but it's gonna stay in place. We are still modifying and tweaking the automated control for the system, which that's a whole nother podcast we can do someday. And we're also looking at how can we now adapt the system to doing pest management applications or fertigation pest applications. You know, it's been done with the other systems and designs that are out there across the country and we want to look at what can we do to provide added value to this system that Once again, still at a low cost option.

C Christa Hartsook 25:04

You bet that makes sense. Once you have the system in place, how else could you utilize it?

J Joe Hannan 25:08

Right if we can use it for frost protection, if we can use it for pest management, if we can use it for applying our fertility. And we also think we might be able to use it to cool down the trees during the summer. So to keep them from getting overstressed on rolling those 95-100 degree days, and so there's lots of options for the system is just need to gather more data and experience with it.

C Christa Hartsook 25:33

The shirt that makes sense. Joe, anything else that we need to know today?

J Joe Hannan 25:38

Yes, umm colder temperatures are coming, be prepared, have blankets on hand. And I should also say thank you to the specialty crop block grant program for funding our project.

C Christa Hartsook 25:53

Yeah, definitely a worthwhile program and worthwhile research that came out of this. So that's great.

J Joe Hannan 25:58

Yeah, eventually just it will happen that the system will get tested under a freeze evetn and we will be able to say definitively Yes, let's go this route.

C Christa Hartsook 26:07

Yep. That makes sense. Joe, as always, thanks for being on today.

J Joe Hannan 26:11

Yep. Thank you for having me, Christa. Appreciate it.

C Christa Hartsook 26:14

All right, take care.

J Joe Hannan 26:15

You too.

C Christa Hartsook 26:15

If you need more information on Joe's Apple frost research. You can check out the recent article in the acreage living newsletter available at www dot extension dot iastate.edu/small farms