Eco-Friendly IPM Approaches for Codling Moth Management

Presenter: Ajay Giri
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JANA HEXTER: good afternoon everyone uh I am Jana Hexter I'm with the Northeastern IPM Center and uh it's a beautiful June day here in uh in Ithaca, New York, finally it has stopped raining for a few days and uh I am excited to uh welcome you today uh on a presentation eco-friendly IPM approaches for codling moth management and uh before I introduce you to our guest speaker I'm going to go through a little few housekeeping things so this presentation was funded through the Northeastern IPM Center through a grant from uh USDA NIFA uh Crop Protection and Pest Management Regional Coordination Program and this is being transcribed so if you would like to see a transcription if you just scroll on your menu bar you should see an option for choosing for transcription um it is being recorded and it will be posted on our website in about a week and uh this is the link here but you don't need to save it because um I will email everybody who is registered for this uh webinar today we would love your questions uh Ajay has uh split this presentation up into five sections he's going to stop at the end of each section uh for your questions so please feel free to pop those and it's most helpful for me if you can use the Q&A feature rather than the chat because it's harder for me to keep track of chat so um if you click on your menu bar for uh Zoom which if you um scroll your mouse at the top or the bottom a black bar should pop pop up and one of those options uh should be a box with two boxes that says Q&A if you click on there you can ask a question and you can also do so anonymously so feel free to do that so I'm delighted to introduce our uh presenter today whose uh little bio has lots of words that I may twist my tongue around so uh I am I am not a scientist and I don't have a degree in plant and soil sciences so you'll have to excuse me if I if I mess it up so uh Ajay Pratap Giri uh is a doctoral research uh student or Ph.D. candidate at the Stockbridge School of Agriculture at the University of Massachusetts in Amherst his uh doctoral research focuses on evaluating eco-friendly biocidal drift reduction adjuvants using um essential oil emulsions Ajay holds a master's degree in plants and soil science from UMass Amherst where he studied the attractiveness of semiochemicals to multiple uh tortricid uh pests in apple orchards he's

published seven peer-reviewed journal articles and more than 15 extension articles contributing significantly to the advancement of sustainable agriculture and integrated pest management with extensive experience in applied research, extension and outreach his work primarily supports innovative and eco-friendly uh pest management strategies so uh welcome Ajay it is lovely to have you here and I realize I mispronounced it it's Ajay Giri not "Jiri" there we go

AJAY GIRI: that's good yeah

JANA HEXTER: all right so before we begin uh you will see a poll popping up on your screen if it doesn't pop up on your screen if you're on a phone or a laptop or something that it doesn't pop up do not worry about it uh but you should see three quick questions and this will help Ajay uh have a better understanding of who is on the call and how he might tailor his presentation to your needs so I will be quiet while that happens all right well 90% of people have uh have answered the poll so I will end that I will share the results uh we have about uh 20% farmer-grower, 30% extension, um 7% students and then a smattering of other folks who are interested in this uh topic um and um how knowledgeable are you about eco-friendly IPM approaches for codling moth management and the vast majority uh almost 75% not at all knowledgeable or somewhat knowledgeable so um and then how knowledgeable are you about codling moth biology uh same there we've got uh close to 80% um of uh actually yeah of people who are not at all knowledgeable or somewhat knowledgeable so given that it's perfect that you are here it is perfect that Ajay has been uh has been working and studying so hard for years to give you some great information so with that I will uh be quiet and turn it over to Ajay

AJAY GIRI: hello everyone uh good afternoon and thank you Jana for the lovely introduction and first of all I'd like to thank the uh Northeastern IPM Center for the award and giving me the opportunity to present today so I would like to welcome you all uh for today's talk on eco-friendly IPM approaches for codling moth management so today we are going to cover codling moth biology just a little bit introduction about the codling moth and then the codling moth monitoring using uh lures and camera trap and then we will discuss about biofix and degree-day

models for codling moth and then I will also discuss about a small study that I did with my SARE research grant which is attract-and-kill system for codling moth and lastly I will also talk about uh residual effect of Bacillus thuringiensis which is Bt against codling moth larva so just a brief introduction of codling moth um so uh codling moth is the major pest of apples and pear in North America it is an invasive pest which enters uh which entered North America back in back 200-- 200 years back um so codling moth belong to the order Lepidoptera and family Tortricidae so the family Tortricidae has other moths that attack apples such as oriental fruit moth, obliquebanded leafroller and redbanded leafroller and codling moth uh has up to two to three generation per season depending on temperature and climatic condition the uh let's talk about the life cycle uh so it has the complete life cycle meaning that it has all four stages: eggs, um larva, pupa and the adult and so how the life cycle goes um so the over codling moth overwinters as a overgrown larva uh inside a silken cocoon uh the whole winters and during early spring right around bloom it pupates and uh around late bloom they start to fly that's the time when you will start to capture them in your traps and when they are flying uh the female moth produces the uh sex pheromone that is detected by the male moth so the male moth will fly off wind towards the female where the plume is being emitted and once mated uh the female moth will produce up to 70 eggs and the eggs are laid singly not in cluster and the eggs can be laid on top of the uh leaf surface or directly on the fruit and it takes about 6 to 14 days depending on temperature for the eggs to hatch and once the eggs are hatched uh the larva enters bores into the fruit um the larva stays inside the fruit up to three to four weeks where it grows, eat the apple, molts several time and when it turns into fifth instar larva it comes out of the apple to pupate either on the bark or uh in the soil so this is uh how they continue their life cycle and as it says like it's up to two to three generation per season so do we have any questions on codling moth biology that I can take

JANA HEXTER: I do . . . no, we don't have any questions yet so keep going

AJAY GIRI: okay sure so now let's talk about the monitoring for codling moth um so why we do monitoring um so in order to detect uh the early infestation or when they first arrive and it promotes the use of targeted pest control methods and it also reduce the need for broad spectrum

pesticides so here uh I have the list of the lures that you can use for codling moth monitoring the first one uh this is uh by Trece uh which is called Pherocon Codling Moth Standard 1X so the lure is loaded in this red septa uh rubber uh it only lasts for four weeks and it's a standard lure um and the threshold is like five moths per week uh five moths per trap per week and if you are doing a mating disruption so mating disruption is a way to confuse the male moth so here in mating disruption let's say you have a block um you are deploying these lures in high densities so that the plume is coming from any direction so the moth gets confused and it will not be mate and the female moth remain unmated uh that means they will lay the unfertilized eggs and that way they don't cause damage so in order to monitor uh the moth population in those mating disrupted orchard uh you need to use a really powerful lure so that they can locate the your monitoring trap so that's why it says 10X so that means it's 10 times powerful and it only last for two to three weeks and then we have other lures um such as this one gray uh halo butyl rubber septa so if the lure is loaded in this rubber septa it can last for eight weeks and usually if the lure says L2 that means long lasting lure and then we also have uh another new um matrix which is called PVC so if the lures are loaded in this matrix uh it can last up to 12 weeks and use is usually denoted by L2-P so all these lures attracts only male because they are based on sex pheromone but we also have the lure that are based on plant volatiles or kairomones for example here uh CMDA Combo-P so here uh the DA stands for pear ester that's the plant volatile and also the acetic acid so these are loaded in this PVC matrix and also the membrane cup and it can attracts both both male and female and the another lure uh which is Combo-S is the only difference is the gray halo butyl septa and the uh PVC matrix so I'm more interested in this lure uh which uh I use in my master's uh research so this lure is Megalure Codling Moth Dual 4K that means the lure is powerful is for codling moth and dual means it has two component uh the PVC matrix and the membrane cup and 4K means it has four kairomone that means four different plant volatiles and to name them uh they are pear ester, acetic acid, DMNT, and pyranoid linalool oxide and it can attract both males and females the study conducted in Washington so that it attracts a lot of females but in Massachusetts we did attract female but not as high as in Washington state and then there is another company called Scentry they also produce codling moth lure and yeah you can tell them by if they are loaded in different material they can last uh

different weeks and then uh we have different type of trap that you can use uh these one are the delta septa trap uh which can be in the color orange or the white and then we also have this wing trap um uh I personally don't prefer this trap because they are very hard to manage um usually they have this sticky bottom and you have to attach them to the top and then we also have the bucket trap um there is no sticky liner inside but you can use a insecticidal strip so that the moth that enters inside can be killed by the insecticide and uh this year uh we are using the camera trap so the camera trap is uh developed by the Barn Owl Technologies and its shape is like a trapezoid shape the camera is mounted on the top in this black uh cylindrical container and there is a rechargeable battery that lasts up to 12 weeks and the sticky liner uh to catch those moth will be housed inside this trap and then uh we had this app called FarmBugReport and this app is still in beta version um so you can't download them from Apple Store and it is only available for iPhone not for Android but I think in future they will develop that too so the camera uploads three pictures a day, one in the morning, another one at noon and the third one at evening and this is how the pictures look like so here you can see the codling moth trapped in this sticky liner and the picture quality is really good you can really tell what moth it is and currently the identification is done manually so we just check the pictures daily um to identify the moth but they are trying to develop the automated identification so that but for that they need more data so this year we are providing the system more data so that they can identify moth in the future and they can also develop a graph um right now we still we we are working so so what are the advantages of monitoring the camera trap um so unlike the delta trap which we use to monitor weekly so this uh camera trap is like more remote I can just see the pictures right now what's happening in the traps and then it gives us daily capture records and also the temporal activity inside that means uh what time of the day either the moth are more active in the morning or in the evening and then we also have this biofix establishment which I will talk later so this uh year we have this camera trap in 15 different location across three states uh Maine, New Hampshire and Massachusetts um so before going to the biofix and degree-days if you have any questions I can answer those

JANA HEXTER: actually I have a question so the temporal data how-- um how it shows you if they're more active in the evening or the morning or the daytime and then that presumably would be when you would want to uh spray or treat is that what why it's useful to ask that

AJAY GIRI: yeah that that is also true and then uh we are also tracking other things beside the captures such as the rainy rain is happening or not or the temperature of the day so yeah we want to know when they will be active they are mostly they mostly responds to the temperature other than anything so if the temperature goes low they will not fly if the temperatures go up they will start to fly uh I will show that in another graph that is really interesting like how they respond to the temperature so but yeah we will get a lot of data from those camera trap

JANA HEXTER: great lovely thank you and we'll move on I don't see any other questions yet

AJAY GIRI: so um let's move on to biofix and degree-days for codling moth um so what is biofix then so biofix is the time when the pest development tracking begins it is usually uh you will consider the biofix usually when there is a first consistent moth captures let's take an example let's say today um June 3 we caught one moth in the trap and then let's say tomorrow we are going to catch one more moth and then next day we catch let's say three moths that means today is the biofix because that's our first capture of the whole season so I can mark today June 3 is the biofix date so from that day you will start to accumulate the degree-days which I will talk a little later so why does this biofix matter so usually after when the biofix happens the biological development of the insect begins that means we can predict when the egg are going to hatch, when the larva will be active and when the second generation will start to fly so all this thing can be tracked based on the biofix and the degree-days model so what is the degree model then so it's a very simple thing uh it's just a heat accumulation um above the base temperature for codling moth uh they are active when the temperature rises above 50 degree Fahrenheit below 50 degree Fahrenheit they will be inactive like they will not respond they will not have any physical development for example for codling uh moth is 50 degree Fahrenheit uh but for oriental fruit moth it's less it's 45 degree Fahrenheit so usually oriental fruit moth shows early in the season

than the codling moth because they have this less base temperature than the codling moth and um yeah is all insects develop faster when the temperature increases and there is a formula to calculate the degree-days if you are doing it manually uh is the maximum temperature of the day added to the minimum temperature of the day which is divided by 2 and then you subtract the base temperature which is 50 degree Fahrenheit uh let's say for example on May 13 uh maximum temperature is 75 degree Fahrenheit and the minimum is 45 degree Fahrenheit that means 120 degree Fahrenheit total which is divided by 2 and if you do the math uh you come up with the 10 degree-days so that means on May 13 you have 10 degree-days uh recorded so if you check this so if you are doing manually you can do it like this so let's say on first column you have date so May 12 we have no captures that means we have zero degree-day accumulation let's say we have our first captures on May 13 then we have to calculate degree-days from that day so let's say we have 10 degree-days on that May 13, 12 on 14, and 11 on 15 and the total degree-day accumulation will be 33 degree-days which you can see in the third column so moving forward uh so how are you going to apply this biofix and degree-day model for codling moth management so yeah if you track if you are tracking that degree-day like that table so when you reach the 100 degree-days that means the some of the codling moth eggs start to hatch maybe you want to apply some kind of ovicidal around this time or maybe horticultural oil to kill the eggs and then around 200 to 250 degree-days that's the time when the uh larval activity peaks and you really want to target around this time to kill the larva before they enter the fruit because once they enter the fruit it's very hard to control they will be protected inside the fruit and uh they will not be ingesting any material that you apply and uh yeah by combining the biofix and degree-day model we have like more precise management and we don't need to apply the unnecessary chemical without knowing anything what happen what is happening in your orchard and it also improved the protection efficiency because we will be targeting this um early instar larva or even the eggs so for myself um I usually use this uh NEWA website is very good

um here um so my so all our camera trap are located in the place which where they already have the um NEWA weather station and so when you go to this website uh you just click uh your farm your or your orchard or if you don't have um the weather station you can uh go to the nearest weather station that will give you roughly uh the same weather data and once you are

there um you can go to the all tools uh that will give you a different pest that you want to monitor for and then uh I go for the codling moth when I click the codling moth um it will it will already set up to a 50 degree base temperature and here let's say my first trap captures was on May 13 so I'll set up May 13 as my first capture date and once you do that uh it will generate a table but the table will not show all the degree-days in here it will show you the current degree-day accumulation but if you want to know from May 13 you can also download this CSV which will download an Excel file and you can see in that spreadsheet um the degree-day accumulation from May 13 until um June 3 and also the forecast for next five or six days so uh so how I uh apply that uh for the management then so let's say May 13 is my biofix date and I have this degree-day accumulation on the third column um so my first spray is going to be around 200 to 250 degree-days uh that's the time when I'm going to spray for the uh first larval activity and uh if the you are catch-- still catching let's say more five moths per trap per week on around this first um spray then you need to go for a second spray that means you have a high pressure of codling moth and then you have to spray around 500 to 600 degree-days or if you are not calculating the degree-days you can also go by days like 10 or 14 days after first spray uh usually what happen with the first generation is that most of the fruits are going drop in June drop there's there's a phenological uh stage called June drop where the apple uh will drop so most of the apple that are already invested will drop down and then uh you'll have the apple that are not invested in your orchard most of the time but you really want to control for the another generation but because that will stay until your harvest so you really want to control for the third generation also so you want to spray your third spray around 1,000 to 1,260 degree-days to target the um second generation and yeah if the pressure remain high definitely go for the fourth spray and this table uh is from Michigan State University and Cornell University so here they show uh when you can spray against this insect and at what degree-days so I'll not go through this table but definitely check this out if you have a problem of codling moth and here um this graph uh shows the codling moth population dynamics uh in Massachusetts orchard from 2023 and 2024 the blue one represents the 2023 and the red is from 2024 and this is uh the average from nine different orchards um here as you can see that the usually the first captures happens around uh second week of May and after that uh they will have a peak close to the end of May to first week of June

and then the population drops down and then they will have the second generation flying out and uh what we have seen in Massachusetts is that we think we have like a third generation which comes later around August so once you start catching codling moth then your traps uh rarely shuts down like if you are doing a weekly captures and because uh what happens with the codling moth is that they have a asynchronous emergence that means they don't come out all at once um they come out different time so they have like a overlapping generations so you have like a sustained captures throughout the season so I'm just marking the potential uh generations or the flights and this data is coming from the camera trap uh now uh unlike that the other graph which is from the weekly data this one shows the daily captures and for some of this location we did had some biofix uh like in the first week from May 13 to May 19 then uh this year uh we have a very uh fluctuating temperature I think so from May 19 to May 26 uh it was really cold and there were some days that went below 50 degrees Fahrenheit that means no codling moth activity and after that prolonged um uh traps are down uh we have captures again from 27 to 31 when the temperature rise up so this morning um we had this uh meeting with fruit growers and we have to recommend what to do so our recommendation was um let's say if you have uh threshold reached on this first week from May 13 to May 18 you definitely need to spray around um later this week because your range of 220 to 250 degree-days is going to cross by June 7 which is Saturday and right now they have this degree-days but let's say on Wednesday or Thursday it will reach 220 to 250 degree-days and this uh uh Wednesday and Thursday is really warm and uh in the forecast I can see that like they have like 20 25 degree-day accumulation each day and then uh what are you going to do with the codling moth that are flying a little late on this third week so our recommendation is that go for a second spray at 400 to 600 degree-days because these moth that are active from 27 May to 31 May are going to lay eggs much later than the moth that were from the first week so we are recommending them to spray again at 500 to 600 degree-days

so the animation is coming late so and uh so this graph is coming from again from the camera trap uh but this is for one location which is in Phillipston so here you can see how the codling moth flight is affected by the temperature so blue bar represent the degree-day accumulation and the red represents the codling moth captures so for this orchard May 13 was

the uh biofix and you can see that it has the consistent captures until May 16 and then rise up because the temperature is rising then suddenly we had this drop down in temperature and traps almost shut down for a week and when the temperature start to rise up again like 12 degree-days 13 degree-days we again have the codling moth captures but on June 1 and June 2 it was again cold and no captures on those days and maybe we are going to see the again it's picking up this later this week with the high temperature so you can see how uh they respond to the temperature yep um that's all for the degree-days and if you have any questions I can answer those

JANA HEXTER: yes we have one question that's come in um are you saying that the apple drop needs to be sprayed as part of controlling the second generation

AJAY GIRI: yeah usually um I have not seen growers like cleaning out those apple that are dropped on the ground but definitely clean it if you have a very high pressure of codling moth because uh what we used to do around June drop is that uh because it's for the research it's not for the management we used to collect these apples that are fallen on the ground that are either infested by plum curculio or codling moth we will just bring those apples to our lab and we will incubate them to see what will come out of those and we will see a lot of insect pests coming out of those so yeah I know it's very hard to do for the growers because they the orchards are really big and it's like extra labor to do those thing but yeah if you have a small orchard uh and if you are like a home gardener or something yeah definitely clean the clean underneath the apple tree yep

JANA HEXTER: great all right thank you very much all right so we're ready to move on and uh we'll be asking questions again in a few minutes if anything comes up for you

AJAY GIRI: sure so now uh we are going to like a more management aspect uh so this uh research is funded by the SARE graduate student research grant and I conducted this study in 2022 and uh so the basic idea of this research was to attract the pest to a certain location in the orchard and then um by applying by using some powerful lures so these lures will attract a lot of

insect in that particular location and when the insect are there we apply some toxic component uh it can be insecticide or some kind of biopesticide to kill them so the basic idea and then we term it like attract-and-kill so the objective of this study was to evaluate the efficacy of an attract-and-kill system for codling moth using a powerful lure and and killing them by using the biopesticide which is DiPel and uh I think I I didn't see any paper on um like codling moth attract-and-kill uh because I think in the past we mostly had this uh pheromone lure which would only attract the males but this time uh we had this Megalure CM Dual 4K which is based on plant volatiles so unlike uh sex pheromone uh these uh plant volatile are used by moth to locate the food source um the potential oviposition site and also habitat so we hypothesized that uh by using this kind of lure which are used for like a finding food source we can gather more moth on those tree and like and and this lure also attracts males and females so if we can attract more female they will be laying more eggs on those trees compared to other trees so our idea was to bring more female moth to that tree so that they can lay eggs on that tree and then apply biopesticide uh which is Bt um when based on the degree-days and biofix so this is the basic design uh of the uh of the experiment so this experiment was conducted in six apple orchards three of them were organic and three were conventional so let's say I had this apple block and um I have I have selected four different trees uh as a treatment so let's say first tree will get the Megalure and we will spray Bt later on and then the second tree will get the lure but we'll not spray any Bt so we want to know how much damage uh the moth can cause here and then the third tree we have no lure but we will spray the Bt that will be more like a grower control and the fourth tree we will not have any lures and we will not spray any Bt so that will be like a control um and then we will also take data from the existing trees to see any spillover effect and the lures were deployed early uh in the May and the injury data were taken at mid-season um around June before June drop and at harvest around August and for each of the six orchard uh we inspected uh 800 fruits for uh codling moth injury

um and so the Bt application was based on the degree-day model so our biofix date was May 20 and uh so the first generation spray was done between 228 to 266 degree-days which was around June 1 to 3 on that year and the second spray was done a little later we were targeting more like a late uh larva than the second generation so it happened around 1,568 to 1,621 degree-

days and here um I have divided the um charts into organic orchard and conventional orchard we do have some variability because uh our replication were very few, three for organic here and three for conventional here but still we can see the trend so for organic orchard here you can see the T1 which had the lure and we apply the Bt the uh injury percentage is around 2.5% but when you don't spray the Bt your injury will goes all the way up to 18% and if you compare that with uh just the spraying we because we are using this experiment in the small block we the moth are attracted to these tree where we have the lure so we didn't see a lot of damage in here and when you don't have any lure and no Bt we didn't have any significant differences but you can definitely see the trend here and for the conventional orchard there is a trend similar to organic orchard but the injury was below 5% and this year we are doing uh the residual toxicity of the insecticide uh for against the codling moth larva and we saw that even after 10 days uh this chemical insecticide are effective against this codling moth larva so we didn't see any conventional any damage uh like breaching the threshold in the conventional orchard

and for the harvest data uh we didn't had a lot of fruit compared to the June because a lot of fruit dropped and uh we didn't see any significant differences but you can definitely see in organic orchard when you have lure and you don't spray you have uh 9% injury

and uh if you compare that with the conventional is pretty low but there is a trend and uh so in conclusion we can see that the Megalure can attract codling moth to certain locations and then based on the degree-days uh if you apply Bacillus thuringiensis in on the in the time when the uh larval hatch is happening then you can also kill the uh larva by applying the Bt uh so yeah so that's all for the attract-and-kill and if you have any questions I can answer those

JANA HEXTER: yes we have uh one question how are codling moth emergence times changing over the years for example over the last 50 years do you have that data

AJAY GIRI: um I so per our silk so we have been tracking the codling moth uh from from when I'm here 2020 uh I didn't have the past data and it's very hard to find the data on like how or when they are emerging usually we have the data seeing like okay they will show up around bloom and we don't know exactly and if you track the apple phenology it's always different like

sometime the if the weather is too cold you'll have late bloom if the weather is high around April then you have the early bloom so it's really hard to track and it's it's it keeps changing so sometime like we have the biofix around May 20 and sometime we have biofix around May 8 so it's very hard to say the exact uh biofix when it's going to happen so so it's important to track the uh degree-days so that's the only way because for this year like we had the period when the temperature went below 50 degree Fahrenheit so no codling moth activity so our degree-days is pushed a little back um so yeah um I hope I answered that question

JANA HEXTER: yeah great um and then we have a couple of other questions did you get any data showing the effect of the lure trees on the rest of the orchard

AJAY GIRI: oh yes I forgot to include that adjacent um tree data here but yeah we we did see uh the trend uh so they are attracted to the nearby trees as well and uh although we didn't had any significant differences on those but yeah they are definitely go to the nearby trees if you have the lures in one tree

JANA HEXTER: all right and uh Clem Clay said, "Would you recommend that an organic grower using the attract-and-kill or would they be better off just spraying Bt at the correct time across their whole orchard?"

AJAY GIRI: yeah I think of yeah I hi Clem yeah it's it's a little bit challenging for an organic grower um because um the material that we have uh that is only effective for very precise period unlike the organic unlike the conventional orchard where the materials can last long like their effect can last until like 10 days or even more than 10 days so yeah tracking degree-days is really important um and uh if we can spray I think we need to have a multiple spray of material such as uh Bacillus thuringiensis because with the weather if the if it's if it's rainy like if if let's say if it's going to rain in next few days then the it's going to wash off so yeah definitely track the degree-days and also the uh moth activity like the flight flight activity and then maybe you need to go for a second spray

JANA HEXTER: okay all right I think that's all the questions we have for the moment so let's carry on

AJAY GIRI: so yeah um so this study is again the part of the SARE grant um so this study was conducted inside the lab so here we were testing the residual effect of Bacillus thuringiensis against uh codling moth larva so before going to the research so how Bt kills the codling moth larva so in order for the Bt to kill the larva so the larva needs to ingest the Bt component so um unlike um so human stomach is mostly acidic that means um even though we ingest the Bt by mistake it will not have any effect on us because bacteria doesn't like the acidic condition but unlike us the um codling moth larva or any caterpillar gut is alkaline so whenever the Bt toxin goes inside their gut uh it will get activated and once the toxin are activated it ruptures the cell wall and the gut component will enters the body cavity and that way they will be paralyzed and they will stop feeding so even though if you apply the Bt you will not see the codling moth larva dead right away it will take some time for them to be dead and they they die about like two to five days after they ingest the Bt they will turn dark in color um so let's go to my study here so for this study I used two larval instar group um so first to two instar is one group and they are like 4 to 10 mm long and the second group will be three to four instar larva which is 11 to 16 mm long and I didn't use the fifth instar larva because they are very hard to kill and uh and for this experiment I collected the apple that are like 2 cm in diameter and uh as a kill component I used the Bt at the recommended dose of 2.38 gram per liter and for uh for the experiment I uh sprayed the apple on day one and I exposed them to 10 codling moth larva and I kept some larva for three days kept some fruits for three days and then I exposed them after three days to the codling moth larva and similarly I did it for the seven days so I use this glass container and then I put one fruit that is spread with Bt and then I expose like 10 codling moth larva inside here and the mortality was taken at 24 hours, 48 hours and 72 hours

and here on the first graph it shows the one day after spray so the mortality here you can see uh although in 24 hours they have ingested some uh the Bt toxin they were not dead they were still moving and uh after 48 hours uh they stopped moving um but they were not dead like

if you if you touch them they will move but they were like in a morbid condition and after 72 hours three days uh they were completely dead so here you can see that uh the first to second instar larva it has 90% mortality and the third to fourth instar larva have 65% mortality and uh I do have some mortality in the control but that is not because of anything it's uh the codling moth larva they are cannibalistic so they will try to eat each other so once uh there's only one fruit for them to eat so they were kind of eating each other as well so the mortality is coming from there and uh so for the three days after the spray uh the mortality decreased um the first to second instar has uh 65% mortality and 34% has below 50% mortality and similarly for seven days after spray um the mortality is less than 50% for all of the thing and the important thing to notice here is that these apples after three days after spray and seven days after spray are inside the lab condition more inside the greenhouse so they were not affected by any rain or like a direct UV rays so that's why we have some mortality but in real life condition um maybe they will only be uh efficient in like first day or second day and if there is a rain event or something like that it will wash off so this was in the lab condition so just to note that so in conclusion uh Bt can kill up to 90% early instar codling moth larva within three days and DiPel is more effective uh at killing younger larva than the older larva and I think that's all for the um the residual toxicity and here uh I'll really like to thank all the growers for giving us their orchard block to do experiment and I would also like to thank uh CropVue, Barn Owl Technologies for giving us the camera trap to do some test and then Stockbridge School of Agriculture, UMass Amherst and SARE grant for funding my research and thank you so much and if you have any questions I'm happy to answer

JANA HEXTER: lovely thank you so much Ajay we have one more question that has uh popped up which is uh do uh from Jeremy DeLisle um, "Do we know how long codling moth larvae are typically outside of the fruit feeding and ingesting Bt?"

AJAY GIRI: oh uh so once the eggs are laid they have to eat so they will first start to eat the skin of the apple so that's the time the Bt needs to be in your hands otherwise if they enters inside and if there's no Bt or no any not any insecticide if they enters inside inside the fruit it's very hard to control so you are targeting like a egg hatch so that's why the degree-days is really important and

uh if you are using a very toxic material that can last long in your crop then you are definitely protected for a long time but if you are using material like Bt then you should really really track the degree-days and know when they are going to hatch

JANA HEXTER: all right okay I think that is all the questions that we have um and uh uh thank you Ajay so we'll carry on we um we'd love to um get some feedback from you um same thing we have uh three questions and should pop up on your screen and so we'll just take a moment so that uh you can answer those questions for us and I'll be quiet while that's happened all right so I will share the results so you can see there is a uh shift there that it's moved to somewhat, moderately and very knowledgeable and uh based on your presentation um and how knowledgeable are you about the biology and there's also a big shift there uh after the presentation and as a result of the of this webinar um how likely are you to increase your implementation of um IPM and there are quite a lot of people there there's like 60 60 more than 60% in very likely and extremely likely so good job Ajay

AJAY GIRI: thank you so much

JANA HEXTER: oh great all right so um we just have a couple of things to go over before the end um um we do not have any uh webinars scheduled for the summer we usually take a break over the summer just because folks are in the fields and uh but we often pick up in the we usually pick up in the fall um uh so look out in August you should see some um some uh new uh Toolbox webinars coming out for September, October, November that kind of time frame um if you would like to be in contact with other people who are interested in codling moths in apples a great way of finding colleagues is to post post a profile about yourself on this website here and uh you can also find colleagues who uh have posted their um profiles there so I don't know if Ajay is on there but I know lots of people are and it's a good way to find each other um and as I mentioned earlier there is a recording um of this webinar and I will send you an email and it takes us about a week just to edit it and and get it ready for you um and it will be up on our website um and you can go back and watch it as many times as you like so I believe that is the

end and so that leaves me to say thank you very very much Ajay for that I mean that was a great presentation really interesting research and uh congratulations on the award and uh thank you for all your work all your hard work in being able to put that together and and do the and do the uh work so and yeah a lot of other people are saying thank you and they appreciate it too so all right and with that I will uh bid everyone adieu to go and enjoy a beautiful June afternoon okay bye-bye

AJAY GIRI: sure thank you bye-bye