Who you gonna call? BUGBUSTERS! Running time: 53 minutes.

Leonard: Wild asparagus plants, certain insects only ate thistles, certain insects only ate grasses. They develop niches and they use plants as food. Certain insects ate other insect species. And of course the plants developed some mechanism of defense against the insects.
Slide 1: Well when agriculture started about 10,000 years ago, those wild plants were domesticated and the insects that had been eating them in the wild moved into the fields. So the insects that had been eating wild asparagus moved into domesticated asparagus fields. And then here in the Americas organized agriculture began about 400 years ago. Many of those plants were brought over, they were not native. Many of those insects came along or adapted to feeding on them. And, of course, some of the native insects adapted to those plants as well. Insecticide spraying here in the United States started about 150 years ago. We're going to start with scene one.

Slide 2: Scene one is talking about these plants that are not native here in America and are eaten by native bugs. And so, the basic thing here is the bugs are here first, this was their land and these non-native plants were brought in. I'm going to talk about rice, artichokes, and hazelnuts.

Slide 3: The rice plant. A couple things you need to know about rice: it's not native to the Americas, it was introduced in the 1690s, it's a grass species and it grows best in flooded fields.

Slide 4: Well what growers found was an insect, it wasn't known as a rice water weevil; it became known as the rice water weevil because it adapted. A native insect adapting to the rice plant. And what the weevil was here first, and what was it doing? It was eating grasses and living in an aquatic environment. So all of a sudden, in the aquatic environment where this weevil lives, 2 million acres of grasses, the rice plant, is dropped in. So the rice water weevil feeds on the rice plant.

Slide 5: And you can see all the roots of the rice plant that have been eaten by the weevil, and that is about a 20 to 40% yield loss. And on the left you can see healthy rice plant roots. This is the reason why 30% of all rice acres are treated for this major pest.

Slide 6: Artichokes in California. Again, a crop that's not native to the United States, production beginning in the early 1900s, 8,000 acres dropped into California. And the important thing to know about artichokes is that it's a thistle.

Slide 7: Well lo and behold, there was an insect in California, native to California, a plume moth, it wasn't known as the Artichoke Plume Moth until the artichoke showed up and the insect adapted to it. It was native to California, it feeds on thistles. Each one of those females can lay up to 170 eggs, and the larvae chew and eat on thistles. And the artichokes were a great breakfast, lunch, and dinner for this insect.

Slide 8: Artichoke Plume Moth damage, before the use of insecticides in California, 50 – 70% of those artichokes were wormy due to that insect. Currently artichokes are sprayed 8 to 10 times with insecticide 96 to 100% of those worms being killed.

Slide 9: Hazelnuts, also known as Filberts up in Oregon. Not a native species. 33,000 acres of a nut crop just being dropped into Oregon with the industry beginning in the 1920s.

Slide 10: And of course, you know the theme right now, the Filbertworm, a moth, was in Oregon, in the Northwest, native in that part of the country, and had been feeding on acorns and oaks. All of a sudden there’s 33,000 acres of a food source, a nut crop, Filberts.

Slide 11: And here you see a picture of a Filbert, or hazelnut that has been cracked open, you can see the worm that has exited, you can see the damage left behind by the worm and the frass left behind as well. You can see the numbers, in unsprayed orchards 20% of the nuts contain filbertworms, 95% of the hazelnuts acres are sprayed and have been sprayed for a long time and the infestations are reduced to well below 1 tenth of 1%.

Slide 12: Scene 2. For centuries, plants and bugs live together happily; native peoples ate for free here in the Americas. And then you know the businessman came to feed city people and the bugs had to die. So what was okay in nature, in the natural world, became unacceptable when these crops were commercialized. I’m going to talk about blueberries and pecans.

Slide 13: The wild blueberries in Maine have been there for centuries. They grow on the forest floor. Native Americans ate these blueberries for free, obviously, fresh and dried. Sea coast families would make a day out of it, going into the forest, picking blueberries and eating them for free. And this had been going on for centuries.

Slide 14: Well then the businessman came and the blueberries were commercialized. The timber lands were cleared, trespassers stopped in the 1920s. And they started canning the blueberries. Today we get 80 million pounds of processed, canned, and frozen blueberries out of Maine. But that industry was almost dead on arrival, as you can see in 1924, several of those large shipments were condemned by the FDA because there were maggots inside.

Slide 15: Now this is the cause of the infestation: the Blueberry Maggot, been feeding on blueberries for centuries in Maine. And you can see the fly, she lays an egg in the blueberry, the egg hatches out and there’s a larvae feeding inside the blueberry. And each female fly can lay up to 100 eggs.

Slide 16: Well here’s some records from the processors in Maine that kept track of what they called Maggot-clean blueberries. When they started that industry, in the 20s, 1927, 1928, only about 20% of their blueberries were maggot-clean. 80% of the blueberries in those cans had maggot problems. And then they started spraying 1928. They started using arsenic and as you can see by 1931 their records indicated that they were about 100% clean of maggots and so what was acceptable in sort of the natural world was not acceptable and so spraying began.

Slide 17: This is the native habitat of the pecan tree in America. This is a native tree, it grows wild in river valleys down in Louisiana, Texas and Arkansas, been there for thousands, probably millions of years.

Slide 18: The Pecan Weevil evolved with the pecan tree. And the pecan weevil, our friend from the top of the show, only fed on pecans and hickories, that was the weevil's natural niche in the environment. And you can see the larvae; the egg is laid right in the pecan, the larvae hatches out and eats the pecan.

Slide 19: Well the pecan tree developed a defense mechanism against the insect, and the way it worked was the trees produce a light crop for 4 to 7 years and there weren't enough nuts there to keep a big population of insects, so the insects starved for 4 to 7 years. And then the tree came along in the 5^{th} or 8^{th} year and produced an enormous crop of pecans, and there were so many pecans then that the insects couldn't destroy them all. It was the way the pecan tree evolved, over time, a defense mechanism against the pecan weevil.

Slide 20: But then the businessmen came. The businessmen came into the southeast into Georgia and Mississippi, and they planted 160,000 acres of pecan trees, not wild trees now, domesticated trees, they planted them in rows.

Slide 21: And they maintained stable production, as you can see by using fertilizer and zinc sprays, they irrigated, they pruned, and they got those pecan trees to produce a good crop every year. So they've kind of messed up now the balance that had been worked out between the pecan weevils and the trees.

Slide 22: So the pecan weevil's populations exploded. All of a sudden in the commercial world of pecan growing they had nuts every year and so their populations exploded. The balance they had in nature had been upset and in the 1930s, pecan weevils destroyed about 40% of the commercial crop in the southeast, this was unacceptable to business people, they started using insecticides, and now the populations are reduced by 99%.

Slide 23: Scene 3. For a long time, a lot of crops were grown in the United States with no need for insecticides, and then new bug species showed up, they came over, they followed the crop over from Europe or Asia and that's when growers started having to kill those bugs. We call this "The New Bugs on the Block" and I'm going to talk about asparagus and avocados

Slide 24: Asparagus, I'm going to talk about CA and WA, where about 85% of our asparagus is grown, 165 million pounds a year. That industry began in about 1900.

Slide 25: Well the asparagus aphid was one of those insects that had a niche in the environment. And what the asparagus aphid does is it only feeds on the asparagus fern, it doesn't feed on any other plant, it doesn't feed on asparagus spears, it only feeds on the fern. And that's what it had been doing in the wild, and that's what it did in Europe. It's native to Europe, it was first found here in the US in NJ in 1969, and then in WA in 1979, in Ca in 1984. So in CA and WA, they had been growing asparagus for about 80 years and this insect was not there, they didn't have to worry about it.

Slide 26: So when it showed up, it just wreaked havoc with their crops, you can see this field shot of damaged ferns, each would be a nice, bushy asparagus fern plants and you can see they've just been decimated by the aphid. The plant stands in WA were reduced 35% in 1980.

Slide 27: In CA, this is a picture of an asparagus aphid flight. That is not snow, those are asparagus aphids coating the ground and flying around. The populations were so great in Riverside County; there was a permanent reduction of 85% of asparagus because these populations were so incredible.

Slide 28: Washington State University did a nice study of the importance of insecticides for controlling this insect, and you can see their conclusion: "Without an effective insecticide for asparagus aphid –which had not been a pest for 80 years in these two states, it just showed up about 20 years ago there would be- a total collapse of the California and Washington asparagus industry." And this was a study cited by the EPA in maintaining registrations of insecticides to deal with this problem.

Slide 29: California avocados, a beautiful fruit, we have about 380 million pounds produced, a very valuable crop to growers, $356 million. See the value listed $6,000 per acre, a very valuable crop. And all avocados in California are sold fresh, if you're buying guacamole in bags or jars in the supermarket, those avocados are grown elsewhere, mostly in Mexico. All of the avocados that are grown in CA are sold in the fresh market, so they really have to be visually appealing.

Slide 30: The avocado thrips was not a problem until 1996 in CA, and its not a problem anywhere else in the world, for some reason this thrips targets avocados grown in California, maybe its because they are grown so far north, its cooler in CA than elsewhere. It feeds only on avocados, it not a problem anywhere else, it feeds only on avocados, it showed up in 1996.

Slide 31: And this is what it does. The avocado thrips scars the outside of the avocado. Now these avocados are perfect inside, its just the outside that has this very severe brown scarring, and the growers report that these avocados sell for about 40% less, the would lose about $2,400 of income per acre with this kind of scarring. So they were very proud of themselves for many years with growing avocados in CA, because they hardly used insecticide.

Slide 32: You can see this data from the CA DPR, in 1990 through about '96; you know a few thousand acres treated, but then when the avocado thrips showed up, the insecticide use really skyrocketed. As you can see now, just about all the avocados are treated with recently registered insecticides to deal with this problem.

Slide 33: Scene 4. Without insecticides, crops would have bug-feeding blemishes, unappealing to consumers. That certainly was the case with the avocados we just looked at. I'm going to talk about a couple of other crops that have this sort of problem too and these crops are nectarines and sunflowers.

Slide 34: The nectarine, the hairless peach, you know a lot of its appeal is its appearance. It's a beautiful fruit. Again, California producing about 600 million pounds, $100 million in value. Much more valuable on a per pound basis than the peach, for example.

Slide 35: California nectarine production, you know it had been growing, maybe not growing so much back in the 1930s, back in those days kind of down around 10 million pounds. And you can see when growth really started with nectarine production right there in the early 1950s, and it was when DDT was introduced. When DDT was introduced and there was an effective insecticide, was when this industry, the nectarine industry in CA, really became profitable because of controls of key insects. And ever since, ever since those early days, insecticides have been used to maintain and sustain nectarine production.

Slide 36: Well, what's the problem? The problem is the Western Flower Thrips. This is a tiny little insect, 3 hundredths of an inch long. Very, very small. Control of this insect makes profitable nectarine growing possible in CA. And this was the insect that was targeted with those early DDT sprays and the sprays ever since.

Slide 37: And this is what they do. All the Western Flower Thrips does to nectarines is to feed on the surface, they just go around on the surface and they scar the surface in their feeding. And what happens though, as the nectarine grows, those blemishes grow as well. Only on the surface, but you can have 80% incidence in your nectarine orchards with this problem if you don't spray, and the value is reduced by about 25%. So this is only on the surface, but instead of having an industry worth 100 million dollars, with this blemish, it would only be worth 75 million dollars.

Slide 38: Sunflowers in the upper Midwest, in North Dakota, South Dakota and Minnesota. Close to 2 million acres, 80% of the sunflower's production being used for oil. I'm not going to be talking about the oil; I'm going to be talking about the 20% of the sunflower seeds that are grown for human food, for snacks, for muffins, for cereal mixes, that sort of stuff. About 500 million pounds.

Slide 39: There are 3 insect pests in the upper Midwest that feed directly on the sunflower seed. The Red Sunflower Seed Weevil, the Banded Sunflower Moth and the Lygus Bug. They feed directly on the seed.

Slide 40: And here's the damage they do: the Red Sunflower Seed Weevil, you can see some punctures, with the Banded Sunflower Moth you can see some darkened areas where they fed on the seeds, and the Lygus Bug, the damage there is called kernel brown spot, there's little brown spots left behind where that insect has inserted its mouth part into the seed.

Slide 41: Well they have standards; the Sunflower Processors have standards for this kind of damage. They will not accept for the human consumption food market any sunflower shipments that have more than 2% damage from insects, and kernel brown spot is almost totally unacceptable, they won't accept anything above, you know, you can see .5%.

Slide 42: So sunflower seeds, for food in the upper Midwest, 100% of those acres are sprayed. And they're sprayed twice with insecticides, and those two sprayings kill all 3 insects. And you can see without those insecticide sprays, they would probably have insect damage exceeding 10%. The standard is 2%, for kernel brown spot it's a half of a percent. So again, the sunflower processors don't want consumers opening bags of sunflower seeds and having every 10^{th} seed with one of those blemishes, and that's why they kill these insects.

Slide 43: Scene 5. Cancer causing substances would be present in food without the use of insecticides to kill insects, in other words I'm going to talk about aflatoxins and the problem of cancer causing substances in food. And the 2 crops would be peanuts and pistachios.

Slide 44: Our growers produce about 3 billion pounds of peanuts in very hot, droughty areas like Texas, OK, GA, AL, and FL. Very hot, droughty.

Slide 45: And this pest, the lesser cornstalk borer does very, very well in these regions, and the lesser cornstalk borer just by itself is a nasty pest for growers, and can reduce yields by 70% just on its own.

Slide 46: But it does something else in that it carries *Aspergillus* fungi on its body and in its gut. What happens is there's about a 94% correlation between the lesser cornstalk borer, you can see the borer damaging this peanut, and you can see the fungi, the *Aspergillus* fungus growing on the areas damaged by the insect. 50% of the larvae carry the fungal spores in their bodies. And so there's this real correlation between lesser cornstalk borer and *Aspergillus* fungi.

Slide 47: But why do we worry about *Aspergillus* fungi? We worry about it because of aflatoxins. Aflatoxins are chemical metabolites that are produced by the fungi, so when you have *Aspergillus* fungi, you will get aflatoxins in your peanuts. And as you know, aflatoxins are in addition to being carcinogenic; they are acutely toxic as well. So there's this relationship between the lesser cornstalk borer, the *Aspergillus* fungi and aflatoxins.

Slide 48: And here's a peanut just coated with *Aspergillus* and so the peanut is going to be very, very high in aflatoxin. The standard in the US is 20 ppb for aflatoxin in food.

I've seen studies where they've tested insecticides against the lesser cornstalk borer, and in the untreated areas, they had aflatoxin levels above 100 ppb and those were knocked down to under 20 because they killed the insect that spread the fungi that led to the aflatoxin.

Slide 49: Now I'll switch gears and talk about pistachios. Pistachios again coming out of CA, 350 million pounds a year and it's the only nut where the shell opens on the tree. You know, you're familiar with pistachios, the shell opens on the tree, but the hulls usually don't. The hulls around the nut in the shell usually don't open on the tree, but some of them do, some of the protective hulls open on the tree as well.

Slide 50: Well when that happens, it creates an opening for the navel orangeworm. The navel orangeworm, seeing hulls that are open, where the shells are open, lays its eggs directly inside of those splits. About 80% of the pistachios in CA are sprayed for navel orangeworm and those sprayings reduce the infestation from about 4% to less than 1%.

Slide 51: Why do they do that? Well US standards, again, for aflatoxin being 20 ppb. The navel orangeworm infested pistachios account for 84% of the aflatoxin in pistachio nuts. And so just a 1% infestation of navel orangeworms, and a 4% certainly will get you aflatoxin contamination above that 20 ppb. So they're aiming to be below 1% infestation so that their resulting aflatoxin numbers will be below that 20 ppb.

Slide 52: Even tighter than that when you consider the EU. In the EU, the aflatoxin standard is 4 ppb, and to show you how important control of this insect is, prior to 1997 you can see Iran provided 100% of the EU market, but they had terrible aflatoxin concerns and they saw their European market reduce by 50%. And that created an opening for US growers. Because of really good control of the navel orangeworm here in the US, there were less concerns with accepting US pistachios and meeting the standards. So pistachio growers control that insect to alleviate any concern about aflatoxin.

Slide 53: Scene 6. Many bugs are killed to keep them out of canned and processed foods. Insect contamination is considered filth by the FDA in processed food. I'll give you a couple examples today: spinach and raspberries.

Slide 54: Washington and Oregon producing about 87 million pounds of raspberries and they're all grown for the processed market. They are harvested and they are very quickly frozen.

Slide 55: Now back in the 1940s and the 1950s, for a long time raspberries were hand-harvested, you would have 15 to 20 workers per acre, 380 hours of labor per acre, pulling each raspberry off of the plant and putting them in baskets. Very, very expensive, over a thousand dollars just to harvest the berries.

Slide 56: They moved to mechanically harvesting raspberries about 10, 15 years ago. And what these mechanical harvesters do is they go up and down the raspberry vines, they knock the raspberries into baskets, and it really reduces their costs, they don't have the same number of labor costs required. But obviously any insects that are in those raspberries vines get knocked into the baskets as well. So when the workers are pulling them off, the workers don't harvest the insects, but when the machines do it, they are getting the insects as well as the raspberries.

Slide 57: And this is what could happen to your processed raspberries if the insects were harvested along with the raspberries. You have insects crawling around on your raspberries. You'll be happy to know that the FDA's requirement is 4 larvae per 500 grams, and obviously most processors of raspberries require zero.

Slide 58: So raspberries are sprayed just before harvest out in Oregon and Washington. And they're spraying and they kill about 98% of the insects with this clean up spray. And these are not necessarily insects that are eating the raspberries; these are insects that are at the wrong place at the wrong time. These can be just incidental insects that are kind of passing through, but because they would contaminate the harvested crop, they're killed.

Slide 59: Now how do they handle organic raspberries out in this part of the country? Well, all the organic raspberries are harvested by hand. So they've gone back to the old way of doing things, it's very expensive now, labor is very expensive, but this worker will just get the raspberry and not bring the insect along with it. It's the mechanically harvested raspberries, which is most of the crop having this problem.

Slide 60: Well you know what crop I'm going to be talking about here, I'm going to be talking about Popeye's favorite crop, spinach. Now this picture is actually in front of Crystal City, TX's city hall, they fancy themselves as the spinach capital of the world. And indeed down in Texas, OK, and AR, for many years ahead of the processed, canned spinach industry in the US, 100 million pounds a year.

Slide 61: Their problem, their key pest is an aphid. And it's the green peach aphid, and the green peach aphid, again, is not necessarily damaging the spinach plant, what they do is they get on the underside of the leaf and it protects them from the wind and the cold and they sort of hide out under the spinach plant. But when those mechanical harvesters go through there, they harvest the spinach and they also harvest these little tiny insects as you can see on the bottom of the leaves.

Slide 62: You'll be happy to know that the FDA has standards for the allowable aphids in a can of spinach. In the 1930s, the FDA allowed 500 aphids per pound of spinach and they tightened that up in 1972 to 250 aphids per pound of spinach. Now most processors, of course, again require zero contamination.

Slide 63: Back in the day, back before there were effective insecticides, about 20% of the spinach in that area, in AR, OK, and TX, was not harvested. They would look at the fields just before harvesting and they would say "there are too many aphids in here; we're not going to harvest all this field because we're going to get this contamination." So you can see a picture of them plowing under a field here, because they looked at the field and said it was too high. And that doesn't happen anymore because there are effective insecticides to kill the aphids.

Slide 64: Scene 7. Without insecticides to kill bugs, there would be no sweet corn grown in FL and there would be no beer. So we've subtitled this "This bug's for you," and we'll make an exclusion for **Eddy Bran** of course. But I'm going to be talking about hops and sweet corn.

Slide 65: And I better deal with your concerns about not having any beer if there were no insecticides, and it's of course related to the hops that are used to flavor beer. Our growers in the Northwest produce enough hops each year to flavor 9 billion gallons of beer. You see the hops cones there, and that's where the flavorings are, inside the hop cones and they are extracted to flavor beer.

Slide 66: Well the hop aphid is one of their key insect pests. The hop aphid, million and billions of these aphids, settling on the hop plants and sticking their mouths in and sucking juices out of the hop plant. And 100%, the hop industry estimates, 100% US hop acreage is infected with this insect.

Slide 67: Now what the aphid does, it's sucking all these juices out of the hop plant and it processes the juices and excretes, it excretes a large amount of sugar coming out in its excrement. And the excrement is called honeydew, that's a polite word for aphid excrement. And so you see these whitish areas on the hop leaves, that's where the aphid has excreted these large amounts of honeydew containing these sugars.

Slide 68: Well what's the problem with that? Well the problem is that sooty mold then grows on the honeydew. So you have a hop cone there on the left where you've had the aphids excrete all this honeydew and then mold grows on that sugary mass that's on the cone. And so the hop cone with the sooty mold isn't going to produce the flavorings that the beer companies want to flavor beer. You can see the healthy cone on the right, looking quite different.

Slide 69: And in the hops vines out in the field, you know aphid-infested vines there on the left, they're turning brown, all those cones are infested with the aphid, they get the honeydew, the sooty mold. You can see where the aphids are killed there on the right; you've got nice, healthy hop cones. And the hop industry is real clear on this, without effective insecticides 100% of Northwest hops would be totally unmarketable, totally unacceptable due to that sooty mold resulting from the aphids feeding. And we would literally lose all hop production in the US without insecticides to kill that pest.

Slide 70: Let's talk about sweet corn down in FL. We talk about FL because its our number one fresh sweet corn producing state, 560 million pounds of fresh sweet corn coming out of FL. If you're eating sweet corn in the winter, the fall or the spring up here in the East, it's coming out of FL. That's our number one fresh sweet corn producing state.

Slide 71: The problem is the corn earworm. Got the male and female moths and they get together and each one of those females can lay about 1,500 eggs, and she lays them right on sweet corn plants down in FL. Over winter in FL they are always around, and the baby larvae, as you can see, going right in and starting to feed on the sweet corn.

Slide 72: This is what FL sweet corn would look like without insecticides. If you look at any of the insecticide tests that they've done down in FL, in the uncontrolled check 96 to 100% of the sweet corn are damaged with worms without insecticides.

Slide 73: So this is the history of FL sweet corn production. Yeah we get close to 600 million pounds of sweet corn out of FL, but that didn't start until 1947. They could not grow sweet corn without controlling for insects before DDT came along. So the establishment of the industry owes its very existence to the use of insecticides, which have been used on 100% of the acres ever since.

Slide 74: So in our studies basically we talk about insecticides being sprayed 10 to 14 times every year on the sweet corn acres in FL. And the Farm Bureau and other analysts have made clear without those insecticide sprays there would be no commercial production. And if you think about it, the commercial production did not exist before there were insecticides, all of the ears are damaged in their test plots and so I think we're pretty safe to say without insecticides there would be no sweet corn coming out of FL.

Slide 75: Alright, Scene 8. I'm going to shift gears a little bit and start to talk about some of the other ways of controlling insects, using predatory bugs. "It's a bug eat bug world." And using biological controls, using other bugs as natural controls. And what I'm going to talk about is that for many crops these natural controls either do not provide effective control or they work best when you combine them with insecticides. And I'll talk about green peas, sugar cane, alfalfa and strawberries.

Slide 76: Green peas up in WA and OR, about a third of the US acres and production, and that commercial production beginning in the Northwest in about 1920.

Slide 77: Well again, it was almost dead on arrival because of the pea aphid. 1934 an outbreak of the pea aphid in OR and you can see the difference between the aphid damage and undamaged pea pods. The aphids feeding on the plants, sucking out juices, and the aphid damage pods being withered and yield a lot less. And you can see half of the crop in part of the state was destroyed, and all of the crop in another part of the state was destroyed by the pea aphids. So they had to find a way of controlling it.

Slide 78: Well we all know that lady beetles eat aphids. It's well known and we're all taught that and we have picture of a lady beetle eating an aphid. And so what they did was, back in the day, they went to CA and got several hundred thousand lady beetles and they imported them and released them in OR in 1935 and they promptly all flew away. They did not do the job, these are general predators, they aren't targeted specifically at the pea aphid and the conditions just weren't right for the lady beetle to attack the pea aphid in OR.

Slide 79: And so how’s the pea aphid been controlled to sustain the pea industry out there? It’s been with insecticides, the early insecticides were compounds like Rotenone and Nicotine, switching to DDT, using Parathion for many decades, and using Dimethoate since the early 1990s because the natural predators aren’t anywhere as effective as these chemicals.

Slide 80: Louisiana sugarcane. About 455,000 acres of sugarcane in LA, 3 Billion pounds of sugar, it was begun by the French back in the 1720s, they wanted to see if they could produce sugar cane profitably in LA. The thing to remember about it is that LA is about the farthest north of the states, and actually the areas in the world where sugarcane is produced.

Slide 81: Their key insect pest is the sugarcane borer. And in these sugarcane stalks, you can see the borer in there; you can see the frass and the damage that is being done inside the sugarcane stalk. In the 1920s the borer destroyed 30% of the LA crop. And it’s not a problem anywhere else in the world, in other parts of the world this is not a problem for sugarcane growers. Again, it may be connected with the fact that LA is the farthest north, if you will, the coldest part of the world where sugarcane is grown. They began a serious search for predators in 1925. And they found some; in fact they found 22 predators. In the literature they describe 22 different predators of the sugarcane borer.

Slide 82: And this is one of them, there’s the wasp on the left and the wasp is on sugarcane borer eggs. And what this wasp does is it lays its eggs inside the eggs of the sugarcane borer. And so on the right you see parasitized eggs because in there is the wasp hatched out instead of the sugarcane borer, and the wasp hatches out and eats the borer inside, eats the egg, and so instead of a borer coming out of there, you get the wasp coming out. And so they released 22 predators, but they provide minimal borer control. Again, it might be due to the fact that it’s so far north, they just don’t work as well to control the borer in LA.

Slide 83: Well strange things started to happen back in the 1950s, they began to see these mounds in their fields in LA including their sugarcane fields. These are fire ant mounds, and you certainly don’t want to go kick one of these things. Fire ants were accidentally introduced into LA in the 1950s. And one of the things a fire ant likes to do is to go around and kill things, and the fire ant kills the sugarcane borer, you can see the ant just killing the borer and this is one of the things they found that the fire ant did.

Slide 84: And so what they developed in LA is a combined approach, an IPM approach if you will for controlling the sugarcane borer, and they’ve kind of worked it out. They figure that the fire ant, the predators, provide 16% of the control of the insect, they have **Rhinal** resistance that provides 24% control, those varieties are tougher for the borer to enter, and then the insecticides provide 60% of the control.

Slide 85: So you can see where they search for predators, and the predators didn’t do the whole job, but by combining them with insecticides you get 100% control of the borer with predators, variety resistance and insecticides.

Slide 86: Alfalfa. We’ve got the crop there on the left and we have the product there on the right. The product is milk of course. Alfalfa not being native to the US, introduced in the 1850s, and it’s the main feed for our dairy cows, and so that’s where milk comes from.

Slide 87: The real problem was the alfalfa weevil, and here you have an entomologist with a handful of alfalfa weevils. And so there are thousands of little alfalfa weevils in his hands there. Came into the US in 1904 and it spread to all of the states by 1970. And the alfalfa weevil, likes to eat alfalfa just like our cows do, and so you have a field infested with alfalfa weevils and they will eat the alfalfa plant, that’s what they do.

Slide 88: And it can reduce alfalfa yields by almost 3 tons of alfalfa per acre eaten by the weevils.

Slide 89: And so they start spraying back in the 1970s, 50 to 90% of alfalfa acres in the Eastern US were sprayed to kill the alfalfa weevil, and you can see the difference here between the unsprayed borders where the weevils just ate the alfalfa, and where they were sprayed and you have a lot of dead weevils, but really healthy looking alfalfa.

Slide 90: Well the Dept of Agriculture began the alfalfa weevil control program, and they went around the world and they scoured the world and they found 13 non native insect species that would feed on the weevil. They bred them and they released 16 million of these parasites all across America to see if they would establish themselves and do the job of controlling the alfalfa weevil, and 22 million dollars was spent on this biological control program.

Slide 91: Well let me take you through a few scenes about how these parasites control the weevil. So now you’ve got a wasp here stalking the alfalfa weevil, the parasite is chasing the alfalfa weevil, and when the parasite, when the wasp catches the alfalfa weevil, you can see its inserting an egg, it inserts an egg through the anus of the alfalfa weevil and the wasp is putting its egg inside the body of the alfalfa weevil. And I’m going to describe the mode of action about how this wasp does its thing.

Slide 92: This is a picture of testicles, the testicles of the alfalfa weevil. You probably didn’t think you were going to see this today, but here it is, A) you’ve got nice healthy testicles of the alfalfa weevil, and B) you’ve got testicles of the alfalfa weevil that have been eaten by the internal parasite. That’s what it does, when the wasp egg hatches out inside of the alfalfa weevil, the larvae eats the testicles of the males and the ovaries of the females. And that stops reproduction pretty fast, and when they exit from the alfalfa weevil, they kill the weevil, so that’s how the parasite works.

Slide 93: And here is the bottom line for this biological control program, it really works well in the northeast, in the 10 states in the northeast you know from PA, this parasite finds exactly the right conditions for controlling the populations, and their numbers are large enough so that insecticides are no longer necessary. But from where we're at from MD and VA through GA and the south, it doesn't work, the parasite simply is not effective in controlling the weevils, and so what you have is insecticides are still used here in this part of the country and everywhere except for those 10 northeastern states. And so again, it's a parasite, it works for part of the crop, but certainly not everywhere.

Slide 94: CA strawberries, it's an amazing crop, 20% of the world's supply; producing 1.5 billion pounds of strawberries every year.

Slide 95: One of the key pests being 2 spotted spider mites, and they suck the sap from the strawberry plants and they're the size of a pencil point. If you look at leaves you'll see little dots running around, and that's the spider mites.

Slide 96: They can really lower strawberry yields, you see the plant there in the middle, it's all shriveled up, heavy infestation of 2 spotted spider mites, and the plants are going to yield about 25% less because of the spider mites' damage.

Slide 97: Well back in the 1970s they had terrible problems controlling the spider mites, it's one of these classic cases, EPA and DPR had cancelled several of the insecticides used for spider mites. Several insecticides lost efficacy, building up of resistant populations, and several of the insecticides killed predators, and it was pretty expensive, they were spending 450 bucks an acre, and they had one of these classic cases of resistance, cancellations, damage to predators, and so they searched for an alternative way.

Slide 98: And they found one, they found a predatory mite, that orange mite feeding on the spider mite, okay? They found a predator, they did their research, they released it, and they found that by releasing 320,000 of these predators per acre, it provided effective control, but it did cost them about $2,000 an acre. So yeah, they got effective control with $2,000 an acre, remember they were spending $450 an acre on insecticides, so insecticides with all the problems that they had, were still a better, more cost effective solution to the problem. Well how does it evolve? Over the last 10 or 15 years, new insecticides have been registered through the efforts of the companies, and EPA, and DPR, and the strawberry industry, new selective insecticides have been introduced, registered, they're not harmful to the predators, so now just about all the strawberry fields in CA, what they do, they have the predators out there, they'll release 30,000 predators if they have to for 300 bucks, they apply 2 of those selective applications of insecticides, they get effective control. So the predators by themselves, too expensive. But the predators in combination with selective insecticides are doing a really good job in combination.

Slide 99: So now I'm going to wind up by talking about what really drives choices, and it's economics of course. "Show me the money." Growers choose ways of controlling insects based upon economic factors, so if they had to choose between 2 effective strategies, a biological control, a chemical control, they are going to choose the one that provides the most money for the dollars they spend. So I'm going to talk about eggplants and grapes.

Slide 100: Eggplant will be NJ, and NJ produces about 12% of US production of US production of eggplant, about 20 million pounds a year. Eggplants are related to potatoes, and so the Colorado potato beetle, which is a major pest of potatoes, is also the major pest of eggplants.

Slide 101: And you can see the larvae feeding, they can decimate potato plants, they can decimate eggplant. You can see the eggplants damaged by the Colorado potato beetle yields can go down by 85%.

Slide 102: And again a classic story, back in the 1950s and 60s they used organochlorines, and organophosphates and the beetle developed resistance. 1970s and 80s resistance issues to pyrethroids, they were spraying up to 17 times with the pyrethroids back in the 70s and 80s spending again 450 dollars an acre.

Slide 103: So what they developed was a Colorado potato beetle egg parasite, they found a parasite, and you can see on the left, the mass of beetle eggs and there's a wasp crawling around and you know what's going on here, the wasp is laying its egg inside the egg of the beetle, so there on the right where you have these blackened eggs, you know the wasp is in there, the wasp has parasitized the egg of the beetle, and the wasp in the tests killed 67 to 79% of beetles in eggplant fields.

Slide 104: So the NJ department of agriculture began a biocontrol program back in 1988. The state reared this parasite and they would sign contracts with growers and release about 10,000 wasps per acre. It was still necessary to make 2 insecticide sprays so they sprayed Rotenone. The cost was $162 an acre instead of $450 for what they had been doing with pyrethroids. They got about 10% adoption in 1996, and then the program was discontinued in 1997. Okay, why the heck did that happen?

Slide 105: It happened because a new more effective, more cost effective insecticide was registered. Imidacloprid was registered at this time and so just one application of imidacloprid at planting reduced the larvae by 99%, no reason to make 2 applications during the growing season, costs $55 an acre. NJ department of agriculture knew that nobody would stick with their biocontrol program, biocontrol program $162 an acre, the imidacloprid $55 an acre, and the biocontrol program just went out the window as a result.

Slide 106: I'll wind up talking about grapes in New England, the northeast: NY, PA, MI and OH. 58,000 acres, 600 million pounds of grapes coming out of that area.

Slide 107: The key pest being one of those native insects again, grapes have grown wild, berries have grown wild in this part of the country for centuries, and the grape berry moth attacks grapes and has always attacked wild grapes and then there were grapes grown in vineyards and what it can do is damage 90% of the berries in the vineyard, you can see where that arrow is pointing to a grape berry moth larvae inside of a grape.

Slide 108: So we get to pheromone as a way of controlling the populations. Here's a graphic grape berry moth mating, and you know how this works: the females in the vineyards emitting a pheromone chemical and the male following that plume of pheromone, finds the female, they mate, the fertilized eggs are deposited on the grape, the worm hatches out and eats the grape.

Slide 109: Well what they came up with, researchers came up with a synthetic replica pheromone. They were able to synthesize the chemical to replicate the natural pheromone chemical. And what you see this worker doing is tying these, they look like garbage bag ties, put about 200 ties in an acre in a vineyard, releasing a tiny little fraction of chemical 2/10ths of a pound of pheromone is released.

Slide 110: And then you have grape berry moth mating disruption. You have sexually confused grape berry moth males, because now you have this huge plume of pheromone, some of its coming from the female, but a lot of it is coming from the ties, and the males follow the plume, and they don't find females most of the time, they find these ties, and the males become confused, they can't locate the females, the eggs are not fertilized and there are no worms to hatch out, so this is a classic pheromone control program.

Slide 111: It was commercialized in 1990, there was a lot of great literature describing this, but to this day, 17 years later, as effective as it is, it's still only applied to 1 to 2% of the acres, organic growers use it, but most commercial growers do not use it, and its not used because it costs 2 to 3 times more, insecticides are fairly inexpensive, this program costs a lot more, and it really doesn't solve the whole problem, because although it will sexually confuse the males inside the vineyard, you still have mating going on in the woods nearby. And you don't put your pheromones out in the woods and there's mating there and so you can have fertilized females flying in from the woods and damaging your grapes. As great as this is, it comes down to a question of economics and the insecticides are still cost effective.

Slide 112: And I'll just end up with this slide, it just encapsulates what I found about insecticides and I think what I've shown today: Most crops in the US are attacked by 1 or 2 key insect pests, major pests, for which chemical insecticides provide the most cost-effective solution to pest problems that would cause great loses in the field. And I know this is, in my opinion, why insecticides are the backbone of control, why they're used on 30 to 100% of the 22 different crops I talked about today.

Slide 113: This is our website, we're putting together a national study of the benefits of insecticides, we will have 50 case studies for a go over the history and the purposes and the biology of the insect pests in these 50 crops and we'll calculate the economic impacts of not using insecticides and it will be on this website. We'll have the slideshow, Bug Busters will be up there as well and I think the slide show is also going to be available to you here through your intranet. I hope we have a little bit of time for questions, but that's Bug Busters, and you know Bug Busters I covered 22 of the crops, I still got 28 more crops, so as you know there's going to be a Bug Busters part 2 and we're thinking of calling it "Bad Bug Bad Bug, What You Gonna Do When They Come for You?" And I'll be talking and we'll be trying to rate the 10 worst insect pests in the US, you know I didn't talk about apples, or potatoes, wheat, tomatoes, and so there's still a lot of bad bugs out there that I hope to talk about in my next talk. So if we have time for questions, we have tape.

Q&A Session
Leonard: Yeah.
Woman: And so the only reason for the avocado and nectarine to be sprayed for the thrips is because it's a visual thing, it's mostly on the skin?
Leonard: That is correct. The question is about the nectarines and the avocados, is it just on the skin? And the answer is yes.
Woman: So it doesn't affect the fruit at all?
Leonard: Doesn't affect it at all.
Woman: So do the organic growers allow the thrips and don't spray?
Leonard: Well see that's the organic, if you go in and buy organic avocados, they look pretty darn good. And so what happens is that organic growers actually can spray the same pesticides that are being sprayed on the avocados for example, they spray spinosad, there's a formulation of spinosad that's approved for organic growers, and so the conventional growers are spraying one formulation of spinosad and the organic growers are spraying another.
Woman: I would just think that there would just be an acceptance that it's gonna look a different color but its fine inside, and that people just accept that as part of organic.
Leonard: The question is do people accept cosmetically damaged fruits and vegetables, and this was a big issue about 15 years ago, there was a lot of action here in Washington, studies done: could cosmetic standards be reduced and have a reduction in pesticides going along with that, and the food companies basically were not interested in doing that, consumers will pay top dollar for perfectly looking fruits and vegetables.
Woman: But people want organic probably would pay nowadays different shift than organic desirability….
Leonard: Right, well I think the shift there has gone in the other direction, 15, 20 years ago maybe organics didn't look as good, right now organics look great, and I think a big part of my next presentation on insects will be one of the real benefit stories of insecticides in the US that makes organic fruit and vegetable growing possible. There's just tremendous use of insecticides by organic growers, very effective, very, very effective insecticides that are used.
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