
Resistance Management

Q&A

MODERATOR: DAVE MORTENSON

J. Newsome, University of Arkansas: In this module we have talked a lot about implementing best management practices and getting that information to growers. Obviously, that is not unique to biotech. My question is if you expect that precision agricultural technologies such as variable rate planners and things like that will play a role in the operational aspect of resistance management?

Beckie: Very good question. I wrote a paper on the future of weed control, from a weed control aspect. Today, we have drones. In my opinion, drones are very useful for monitoring and surveillance and the technology is rapidly advancing. We will have to work with FAA stipulations about how far they can go without sightline, etc., but drones are certainly one aspect of precision weed control. We have done a lot of research on weed patch management using GPS, whether in combines or in tractors, mapping weed patches and monitoring them to make sure they don't spread. I see a big role for precision agriculture in terms of mitigating weed resistance.

B. Gwin, Ohio State University: If we want to plan ahead we should use previous records, online tools, things along that line to preempt rather than remediate. Any comments on that?

Storer: I'll tackle that from an insect standpoint. Last I recall, rootworm is very localized in a field, and if we get to the point where that can be recognized early that will give us a strong tool for targeted control.

Mortenson: I might jump in and mention that you and I have worked on such tracking of fields over multiple years, taking existing data from farmers' fields to help guide what you will do in the next year. There is no question there is a benefit to that. The ability

to use the spatial information shows that we will definitely be able to address at least the weed control problems.

C. Mallory-Smith, Oregon State University: Nick, it is my opinion that the companies, those producing insecticides or those producing herbicides, have embraced different cultures around integrated management or resistance management. The companies working on pesticides seem to be much more effective than the herbicide group. Do you have any comment on why that could or why it was?

Storer: I could speculate but one of the key factors is the early involvement of the EPA in insect resistance management. A lot of concerns raised from within the academic community around the risks associated with resistance development were listened to, and when the initial registrations for *Bt* crops came out, we had to develop internal programs to tackle that risk. We have been doing it now for 15–20 years with the insect traits. With emerging glyphosate resistance, you are now seeing a big change in the way we think about herbicide tolerance traits, we now are implementing herbicides with much more stringent stewardship programs than we never dreamed of implementing.

Housenger: Can I just add to that? You know getting to the resistance issue was huge in terms of going forward. It wasn't an easy thing. It wasn't something that growers necessarily supported and certainly industry was pushing to work with us on implementation. All stakeholders will be subject to the same kind of requirements in the future. I think it was a big hurdle to get over but now that it's done it will be a lot easier to impose those requirements

A. Read, Penn State: I have an observation first and then a question. The observation mostly comes from the outside, from the related issues of resistance management in the health care system with respect to infectious disease, cancers and also public health issues. It just staggers me how well organized you guys are, how much regulation there is, and how much science is going on in comparison with what is happening in infectious diseases, where we have very little control, very little regulation, very little pharmaceutical company cooperation. It is a really a staggering state of affairs. The ag sector is well ahead of medicine, which I find most remarkable. So here is my question and it comes from the title of Rick's talk this morning: All four of you seem really sure of your sciences in terms of what the best management practices are and the main challenges seem to be in terms of the regulation of them, the implementation, getting the grower buy-in and so forth, what you might think of as the sociology of the process. Is that really fair, are you really confident in your science? Are you really sure that the rotations are the best way to go? The mixtures may be wrong in some situations but not others? Or do you see that in fact there are open, unknown areas in the actual science of resistance management?

Housenger: I would indicate that we don't know. But time will tell.

Beckie: I would just add that I do believe that you know we are at a crossroads. I think the science is mature. I think we basically know what to do. We have the best management

practices developed, not perfect, rotation is not perfect. Technology is always changing: there is BioDirect down the road, but I would agree that it is the adoption by growers that is crucial. However, as they found in Australia it wasn't until they had a problem that they were forced to implement change. So when the problem gets big enough, that is when growers will be forced to, you know, go to plan B.

Mortenson: I would say that the work we are doing would benefit from a sensitivity analysis as to where the weakest points are. We need to get folks to do things cooperatively at the landscape scale, but there are still uncertainties in some of the control tactics and how effective they really are. We have some work going on where we are seeing surprising results for cover crops, in some cases we are advocating their use as the resistance management plan while in others cover crops are exacerbating the problem. More research must be initiated, but I think the bigger impact is from getting folks to behave responsibly and it seems to me that the question is how effective are these stewardship plans under different names going to be and how do we get them implemented.

R. Roush, Penn State: I have a specific question for Jack and Nick, on the corn rootworm saga, where you showed two years ago you had resistance and it seems to be caused by mixed breeding stock. How important is this problem, since it still remains the only case of *Bt* resistance in the United States, but seems to have the potential of getting away? I am wondering, from both a regulatory standpoint and company standpoint, how serious you see the problem to be and what actions are being taken to deal with it?

Storer: We felt, just like you, that when these products were first launched the resistance profile was greater than we were comfortable with. Having robust resistance programs was an important step. We work with Dow and Monsanto to modify the mode of action to try to reduce that risk. The goal is to get that product in the hands of farmers before resistance has developed to it. I think that has been largely successful. That is complemented with how best management practices are so greatly changing the way growers use the traits that they are being used in a more responsible manner and not just kind of the same year after year after year, something we all recognize has created resistance risks that we need to address. And of course it doesn't stop now. We have new products coming through the pipelines every three or four years.

Housenger: We are taking it very seriously. We took it to our scientific advisory panel for advice. We are proposing certain modifications to prevent further spread of resistance, and I think it does get back to how much growers are adopting or actually how much are they following best management practices that will ultimately determine how successful they are.

T. Shelton, Cornell University: This is directed mostly to Nick, who gave a wonderful presentation but certainly one to engender some questions. The first one would be about the credibility of the Excellence through Stewardship program and the credibility of its audits. Who is going to do that auditing? Is it an independent body?

Storer: Yes, ETS is not an industry association. It was set up by industry but it stands to the side. We are members of ETS, as are a lot of small developers and universities. We just try to get as many organizations involved in the development of biotechnology around the world. There is that broader view of what we are doing. ETS does independent audits and they provide a report on those audits back to the company. They list on their website whether or not a company has passed the audit.

Shelton: The next question might go to Jack or Nick. Would you go so far as to tell growers that they cannot plant corn after corn in a particular area where you have seen some breakdown for corn rootworm resistance?

Storer: We would work with our customers to avoid any mistakes they may have made, so we would encourage growers not to keep planting our product if it didn't work for them last year.

Shelton: Would that mean that you would encourage the lower corn price as well so they are not tempted to do this? In addition, you outlined this mostly for developed countries. What about the small farmers in India, the small farmers in South Africa you are selling products to?

Storer: This is a global program and it applies to every place where we sell *Bt* seed. The initial focus is on Latin America because of issues that need to be dealt with, but it will expand to all countries where we sell.

M. Owen, Ohio State University: Rick, according to Aaron Gasman the evolution of *Bt* resistance is becoming huge and it is getting away. I don't myself believe that we are lacking the technology to manage these issues, and looking at the surveys some of our rural sociologists have done, there was one here recently that came out of the Commodity Classic, and 98% of the growers respond that they are doing everything they can to manage resistances to pests. In my mind that is not necessarily supporting the increasing evolution of resistance to superbugs, and I don't think there is a lack of technology. What is really lacking is the ability to recognize what here recently the problem really is and that is not a technology problem. It is not a biology problem. It is not even an ecology problem. It is a socio-economic problem of scale agriculture has in trying to initiate this at the landscape level. It has to be a community-based program. But farmers do not have the time, and in the upper Midwest we do not have the labor, and right now with the low commodity prices we haven't got the money to get it done. As Hugh Beckie was saying, they are not going to do anything until they have a disaster and then they are going to wonder what happened and it will be too late. Yes, they can fix it, but now a lot of other issues will impact the rest of the production. Increased tillage, water quality issues, higher pesticide usage, and it becomes a real mess. It is, as the sociologist would describe it, a wicked problem. We know what to do. You and I and David and a lot of us have been talking about what to do from the top down for our entire careers. It is not effective. The message has to come from the bottom up. It has to be community based, and there need to be not just carrots but also sticks to induce behavioral changes. I don't see those

happening until it is too late. And I'm not sure I care, because I will be retired soon and will leave it to the younger folks.

Beckie: I just want to add that a farmer once said, "What if you guys weren't doing your jobs, how much worse off would we be?"