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Crop Science: World Class Innovation Platform

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Good afternoon, everyone. I hope you're having a good afternoon and we're helping educate you a little bit more. I'd like to introduce myself. My name is Bob Reiter. I'm the Head of Research for Bayer Crop Science, and I'm going to walk you through the R&D platform and R&D pipeline, and give you a little bit of perspective on why we're so tremendously excited by the combination that we have in terms of the capabilities of the new R&D organisation and where we believe we can shape agriculture and innovation in the future.

I want to start with a slide that you saw earlier today from Liam, which is showing really the opportunity that we have that is being driven fundamentally by the tremendous capabilities that we have in all of these core platforms in our R&D pipeline.

Starting with our breeding capability – which we believe is fundamentally number one in the industry space, and we'll talk in more detail as to why and the capabilities that we have – this is very, very foundational. As Liam alluded to, the seed decision is the very first and most important decision that a grower is going to make. It sets in place a cascade of decisions that a grower will need to make once they've decided both what crop they're going to grow, but what variety of hybrid they're going to put into the field. We can help them with some of that decision making and complement those decisions with additional decisions around crop protection products, trait packages, biologicals, and ultimately that is going to be driven more and more by data science. You'll hear later how customer data also becomes very valuable.

Digital really drives two things for us. One is it's driving our engine internally in terms of the data science and decision making that we use in our R&D platform, and it also allows us to access customer data and help with that customer data, both in making decisions on the farm in terms of management decisions for the grower, but also I believe more and more that customer data will influence how we drive and make decisions within the R&D pipeline.

If we walk through and look at the portfolio that we've brought together with the two organisations; it's tremendously exciting. The number of projects we have actively in the pipeline today is well over 75 projects across our R&D platforms. The value creation that we think we can have just by taking the existing products from the two portfolios, doesn't even begin to consider that I think there will be future opportunities in the future as we bring the biology and the chemistry together.

You can see the depth and array of different products, and the number of products that we have. We have well over 50 advancements in our pipeline this year as we went through our fall harvest from the northern hemisphere, and we made decisions in terms of the progress in our pipeline for

both our crop protection, biological, trait, germplasm, and digital portfolio. It's super exciting to see the depth and breadth of what we have, and really for me also is the great opportunity we have to bring these various pieces together, and we'll talk later about how some of that I believe will come together as far as tailored solutions, where we can look at reducing that variability that growers are experiencing as they look at different parts of their field and operations on the farm.

Just like you heard this morning from other divisions, external innovation is critical and key for us to be successful in this space. As a company and a Crop Science R&D team, one of the things we are very, very focused on is how we will continue to tap into external innovation and appropriately apply and use that in terms of our pipeline, and how we ultimately then can create value and products for our customers. What's been nice to see is the two companies, I would say, had a little different, but very complementary approach in terms of how we tapped into that innovation.

On the Bayer side, for example, they had set up platforms like grants for traits, grants for targets, and open innovation centres that they have around the world, which allow us to uniquely tap into new and novel ideas and to seek out solutions for compelling problems that we might put out there for people to potentially come up with a solution for. They and the legacy Monsanto team also had very strong relationships with academics around the globe in various areas where we were bringing in technology and ideas for our pipeline.

And then if we look on the venture capital side and collaboration side, Monsanto Growth Ventures is now Bayer Growth Ventures, where we're making early stage investments in new ideas, particularly out in California and the east coast of the US, and other areas where new start-ups are emerging in a whole host of different areas in agriculture. We're making investments in those companies and start-ups.

Finally, collaborations are also at the core, and those collaborations range from small companies all the way to joint ventures that you heard with the LEAPS programme, or large company collaborations like historically we had with the Yield and Stress collaboration with BASF. I think it's really important that we have this full spectrum of innovation and collaboration, and one of the strengths I believe we have as a company, as an R&D company pipeline is that we both have tremendous internal R&D capabilities to develop products and ideas from others, and we have of course a tremendous reach in terms of our commercial platform and capability that allows that innovation to be realised in terms of real value creation for farmer customers, and ultimately for the innovators that we collaborate with.

I want to walk you through our various platforms, and just highlight for you some of the things that I think are particularly special about each of those platforms and why they're important, and how they're going to shape the productivity and the assets that we have in each of those platforms.

I'm going to start with breeding, because at the core of our platforms is really that seed component. Breeding is the engine that continues to drive the improvements and the genetic potential of those seeds that we develop. Over the last 20 years or so, we have continuously been investing in technologies to continue to refine and improve the overall breeding process. We've been accelerating that in the last 5-10 years as we've been able to apply some of the capabilities of data science and analytics to the platform to complement the things we were doing, both from an operational perspective and also what we were doing in terms of using our genomics platforms. Today, as I look at our breeding organisation and what we can do it's fundamentally astounding to me how we have so much real time data flow that's occurring in terms of helping to make decisions, and the amount of data that we're generating more and more in an automated fashion.

The other piece that's fundamentally changed is – and I always like to use this example – historically plant breeding data came from the field, and we had large scale pipelines where we

would screen hundreds of thousands of candidate products, using field trials, to get to the data on the yield potential and the genetic potential of that particular hybrid, or that particular candidate variety in the crops that we would breed in. Today we use tremendous amounts of data from the labs, so we fundamentally shifted a huge amount of data collection from the field to the lab.

Right here is a sequencing chip, and with about 50 of these, we are now basically conducting our entire first year of field testing in the laboratory. We've shifted all of our first-year field testing; we do all of the prediction of the products using DNA testing, DNA analysis using sequencing chips. That came about because we had collected the information necessary to build the models and predictions. We've evolved the capabilities in our IT organisation and the analytics that allow us to drive those predictions in an efficient and effective way, and do it cost effectively and even more effectively in terms of output, replacing what we used to do with field trials.

We still conduct a lot of field trials, because at the end of the day we still have to have proof points on the performance of our products in the field. Just to give you a sense of the scale of our capabilities as an organisation, today if you were to take a plot which is a single assessment of a variety or a candidate hybrid, that's about a seven meter long row. We plant enough of those plots to circle the globe twice, so that gives you kind of a context of the scale of the field testing data that gets generated.

The other piece that we've been doing though is breeding is a tremendous numbers game, and we deal with hundreds and thousands of different individual items each year that we have to create seed for, put into planters and get into the ground. We've built automation, tracking and capabilities that – we actually manage more SKUs than Walmart in our logistics platforms -- track and process and put together into organised cassettes. It's kind of like when you get your box from Amazon and it's delivered, and it's got all the items you ordered. Each of those is custom for each individual. We do the same thing with seeds. Those ultimately get put into the ground. We know exactly where that seed was put into the ground, we know what seed was put into the ground, and now we are going to apply a bunch of other technologies that allow us to track the progress and growth, and ultimately the harvest of that plant so that we know its overall performance and all of the attributes of that crop. All of that is happening in real time, so just a fundamental shift over the years in terms of the capability of our engine. For me, it's really exciting to see these changes and how they continue to improve and refine. Many of these concepts – as we'll talk later – in crop protection are also part of how we're evolving some of our other platforms.

The output of all that of course at the end of the day for us is competitive performance in the crops that we breed in. We're very proud of the consistent performance advantage that we continue to see in our programmes, both in corn with a seven bushel advantage with our flagship brand in the U.S., DEKALB, or whether it's on our Xtend soybean in terms of competitive advantage with our germplasm and two bushels per acre, or where we have a clear advantage in terms of the harvestable lint, of where we have over 80lb of lint advantage in our Deltapine brand when we look at our cotton portfolio. What's exciting for me is also when I look into earlier stages of our pipeline, how some of these technologies that I talked to you earlier are going to start to have an impact, and I believe fundamentally will allow us to further extend this lead in the future.

You heard a question earlier today in the general session where someone asked about gene editing. For me gene editing is a very important and potentially very powerful technology, with a range of possible applications. To be clear, it is a complementary technology to the toolbox that we have today in terms of how we do breeding, how we develop traits for the market, and how we develop products in crop protection and biologicals. Gene editing can help to make a difference in terms of how we create biologicals. It can allow us to do things in our seeds that are a little different than what we do in traits. Depending on the kind of changes we make, we know in certain situations the

regulatory path is a little bit easier. It's a very complementary technology, and we think it's going to be a very important one.

Another feature of it is, I would argue it's somewhat of a democratised technology. We hear about lots of academic labs that are using gene editing technology today and are trying to make changes in plants and understand what those changes do. I think it's tremendously powerful for doing genetic studies in the research environment, and there will be some outputs from that that we think could potentially be very exciting and make innovation improvements for customers, for farmers. The technology by itself isn't a product, and ultimately individuals that are doing these things are going to be looking for partners like us, because at the end what you're going to need to do is you're going to have to package that gene edit together with other knowledge and capabilities like our breeding and germplasm, like our trait package, because all these things together are ultimately what a customer purchases. They don't just purchase an edit; they're going to have to purchase that whole package.

The other piece about gene editing is much of what still needs to be developed in the space is partly the technology itself, and making the technology become efficient. A huge part of it also is where you should make changes. Many of the things that people are doing right now are just basically mimics of what already exists in nature. There can be some speed and efficacy benefits of doing that, so that isn't to say that the technology isn't already bringing some advantage, but our genomics knowledge I believe will also be really helpful in collaborating with others that have ideas in gene editing. Our pipeline is now advancing to the point where not only are we working to perfect using the technology, but we have a first project that I can at least show you. We're developing a product for the silage market; this is a product with improved digestibility, so it's really targeted for those farmers that are going to harvest corn crop as a silage crop and feed it primarily to dairy cows. We've made changes in the crop that allow it to have better digestibility properties. This is just the beginning I think of a number of things that you will see over the years that we will be developing.

One of the things we believe very strongly in this space is partnership, and so I'll also highlight. We have a collaboration with Pairwise, which is a company that we helped set up. Part of the reason that we developed it is both to accelerate the development of this technology, and also because it allowed us – it's a company set up with three founders in the gene editing space out of Harvard and MIT Broad, so it allows also to tap into their laboratories, their expertise that Pairwise can then use to help to drive this technology faster.

One of the things that of course we're extremely proud of is the fact that we really are the technology provider in the biotechnology trait space. We have a tremendous reach with our products, with well over 350 million acres that are planted each year to various biotechnology crops and traits. Our job is to maintain a leadership position in this space and continue to enhance and drive our capabilities and the products that we develop out of our pipeline. We continue to refine how we're developing insecticidal proteins, how we identify new proteins for new modes of action against different chemistries for weed control, and then if we can extend this into other spaces as well.

One of the things we continue to focus on is continuing to drive upgrades in our platforms. If we look at both our weed control and our insect control platforms, what you'll see is a consistent set of third, fourth and fifth generation products where we're continuing to refine and add additional or new modes of action for weed or insect control. If you look at our soybean portfolio, you heard already today we just launched the Xtend platform in the last couple of years, and in a couple more years we're going to be launching the XtendFlex platform for soybeans, so we're going to add another mode of action which will be glufosinate, which will add to glyphosate and dicamba.

In the middle of the next decade we're going to have a fourth-generation product. We're going to add more modes of action, and then in the early stages we've got another product coming where we're going to have five modes of action for different chemistries. Continuing to drive and provide upgrades in the market to provide growers with more choice.

What's changed I would say for me over the last years is, when I joined Monsanto, we had just recently launched our Roundup Ready platform for soybeans, and it took about a decade until we then turned and launched Roundup Ready 2 Yield, which was our second-generation product. What you're seeing from our pipeline is that we're accelerating the level of innovation, so these next cycles of products are now coming in about five-year increments as opposed to decade long increments. I think that's a testament to our expertise, knowledge and leadership in this space.

If I look at insect control, it's another area where we've had tremendous success. Look at corn rootworm as an example. Not only are we using BT proteins to control corn rootworm, we're adding in a whole new technology, which is RNA interference. This allows us to then control the pest with a completely new mode of action, which is different than the BT proteins. A tremendous complement to what is out there in the market today, and a real value add for our grower customers because one of the things we always need to manage in different geographies is the development of resistance by the insect pest against these trait controls or the types of controls in the market. This is near launch, and we're only waiting for regulatory approval on this product, but really tremendously exciting and value adding for the industry and for the space.

The second one I'll highlight for you is our second-generation insect control. Liam mentioned to you already that Intacta is a product that we have on almost 60 million acres in Brazil today. Intacta 2 is our next generation product, where we're going to have two additional modes of action to control insect pests, and we're going to add another level of weed control in that product. I think Brett may have highlighted this one for you.

Finally, in cotton, where historically in insect control we've only been able to control lepidopteran, which is above ground pests, and coleopteran, which are below ground pests. Now we have our first product that's going to be launched that will control a class of sucking and piercing insects, so in this case it's lygus and thrips. This is fundamentally ground-breaking for two reasons. First of all, it will control sucking, piercing insects, so it'll be the first of its type. Secondly, these kinds of pests, before traits were introduced, were not the primary problem for a cotton grower. What's happened is, because of the excellent control that we've achieved with our trait portfolio and use of those products by customers, these secondary pests now become much more important to a customer and are much more important to control. There's a lot of value that gets created by being able to control what historically may have been considered a secondary pest, and now is much more important to the market.

Liam mentioned to you this morning short stature corn, and I really want to highlight this particular product for you because to me this is one that I believe is going to change the game in terms of corn production. The reason I believe it's so foundational is because you'd need to think of it a little bit like the Green Revolution. In the Green Revolution, what Norman Borlaug did is he reduced the stature of rice and wheat, and what that did was it allowed farmers to fertilise those crops, get more yield potential out of it, and not end up having the risk of lodging or the crop falling over and losing all of that yield potential. There are attributes of that and the way that was done is somewhat similar for short stature corn as well, but let me walk you through those in more detail. It really comes into three categories.

The first is what I just alluded to, which is when you shorten the stature of the crop the crop now becomes more tolerant to a couple of different problems where the crop could fall over. One of them is root and stalk lodging, which are later season problems that occur with a crop. When that

crop lodges, you lose that potential yield, and then the grower may not have that as part of the harvest.

The second one is what we call green snap. This is where in the middle of the season you've got a very nice growing crop and you have a high wind, and literally the stalk will snap or break, and then you lose the yield.

If you look at those kinds of problems they typically range as being a problem on 5-25% of the acres, depending on the environmental situation, the hybrids that are growing, and the overall environmental conditions that take place. They are always persistent out there in the markets, so for growers this is a real value add.

The second piece is really I would say a message and an opportunity around sustainability. As you saw from the video and from the equipment picture, you can see that the crop is shorter, and now we can run equipment through the field in mid-season that today a grower cannot do. We apply nitrogen in the fall and in the spring, because we can't apply nitrogen in mid-late season. Therefore, what ultimately happens is a lot of that nitrogen that gets applied is never available to the crop; it gets leeched out, it never becomes available, the nutritional needs of the crop are never optimised. By shortening the crop, we're creating management opportunities for nutrition, for example, where a grower can come in mid-season with equipment and they can apply fertiliser in different forms, side dress that crop, and that really allows the crop to be optimally fertilised and have nutrients applied when it really needs it. You can imagine the same thing for crop protection products as well. That creates both an improved sustainability opportunity for the grower and an input opportunity.

The third one I think is probably the biggest and most important, which is if you look at the corn crop, the yield ultimately comes from putting more plants per acre, so crop density. What over the years has been happening is growers are sowing more seeds per acre, year in, year out. That trend line drives the yield potential. What breeding has fundamentally done is it continues to refine and adapt the individual plant so that it can tolerate that increasing density, because when you increase the density of the crops, you create more stress, so the crop is going to have a harder time standing up, being able to get water and nutrients. The great opportunity that comes with short stature corn is I think we're setting a whole new standard in terms of the levels of density that we can put the crop under. It will create a new platform for us to breed on that will allow us, I believe, to drive to higher densities than I think we could have ever achieved biologically with conventional corn, and that translates into yield potential for the grower as well, so I think this is a super exciting platform. It will be really exciting to see how it evolves for us, and we'll be able to further unlock, identify and quantify the value proposition and the opportunity for customers, and ultimately for the business.

When I brought the two organisations together one of the things I was particularly excited about was to learn about our crop protection space, because that was the power alley of the legacy Bayer R&D organisation. What was exciting for me to see is some of the same things that I articulated earlier that we were doing in our biotech and our breeding pipelines. Some of those same concepts are being applied in the crop protection space, and that is historically companies in this space would screen large numbers of molecules and have a funnel in which they would identify efficacy, and then ultimately develop and deregulate those products and make sure that they could pass the appropriate safety screens to get to the market.

The regulatory standards have continued to increase, and the ability to identify efficacious models has become more and more challenging for the entire industry. The changes that we've been making in our pipeline are basically twofold to address those problems.

The first is using a smarter pipeline where we look for leads using genomics knowledge, other types of toxicology knowledge, or other types of data information that we can analytically apply and start in the screening process using smarter leads. A great example of that is NemaStrike. NemaStrike was identified using genomics and other information through the study of nematodes, which then identified a candidate cast of chemistries that we ultimately developed into NemaStrike. This concept of using additional data types is absolutely key to driving more efficiency and more efficacy in the pipeline.

The second piece is we've incorporated a number of additional early safety screens into the pipeline, to identify and reduce the risk of a late stage failure where you end up having a toxicity problem with a particular molecule that you don't identify until late in the regulatory process. By applying additional screening, information and knowledge, and these things will continue to refine and be driven by analytics and data models, using these two approaches we believe we're fundamentally enriching and improving the overall performance of our pipeline. You can see that illustrated in the far-right chart there. In the last three years, we now see where using these approaches we've more than doubled the number of early stage candidates that we have.

Weed control, of the three indications of controlling weeds, disease or insects is the hardest class of chemistries to identify. In fact, in the last 20+ years, the entire industry has not identified a new mode of action. We are not only seeing an enrichment in terms of chemistries that we believe have future commercial application, but we've also identified new, fundamental modes of action to the ones that exist in the market today. That's a huge breakthrough, and particularly exciting. Early days, but I would tell you that it's really exciting to see this approach and this strategy being applied. With organisations coming together I think we can further accelerate what we're doing.

In the biological space both organisations were well invested in biologics, and what we're bringing together I think is very, very complementary, because not only do we have capabilities to look for biologics that can act in a way that helpful for crop protection, but we're also seeing biologicals that will be usable to help increase crop productivity. You can see some of the pictures there where we've identified initially a microbe that has only limited efficacy for a particular fungal disease, and through genetic manipulation what we've been able to do is we've actually enhance that microbe, and now we're seeing levels of efficacy that start to look a lot more like a small molecule. For me, that ability to make enhancements and improvement, and then have something that works quite efficaciously is super exciting. I think we're just at the beginning of that journey on how to do that.

The other piece is also very complementary, which is we have a large screening capability where we're looking for microbes that potentially unlock additional productivity from the crop. These are applied as a seed treatment, and the way they work is fundamentally this. We know that if we sample a teaspoon of soil from a field there are probably about a billion different microbes in there. If we go to different fields, different places and sample, we find that the biologic population of microbes that are in that teaspoon of soil are different. It's similar to the way your microflora are actually uniquely identified with you, and they work in harmony with you in terms of your overall health and performance. The same is true for the crop. By introducing the appropriate microbe into the environment of the plant, those microbes then create an environmental situation that is complementary to the crop and helps that crop to extract nutrients from the soil, and help that crop's productivity. We have a very large engine which we're using to screen for those kinds of microbes that then help the crop, so very complementary and very exciting science that's occurring in this space.

When you bring it all together now with all of these various platforms, I look at tailored solutions really as three buckets. Customer data is very powerful, and what we're using customer data now

to be able to take our products, our seed products, and better predict which hybrid or which variety really should be grown in a particular field, and we can do that in a highly predictive way that ensures greater success and greater yield potential for that customer. That's already on the journey of how we can use digital and our products can bind those two things together to provide a more tailored solution for that customer by customising that seed choice.

As we move back into our pipeline you're going to see more examples, and you have one here on the slide showing the complementarity of our products, or products in the pipeline where we're trying to solve a particular problem for our grower customer and we're going to combine different solutions or make a choice in terms of our own development. Should we invent in a trait for this problem or is it better to invent an insecticide? If you look at the various insect pests in Brazil for soybeans, for example, you can see that some of these pests really are best solved using a trait package. Others of these actually would benefit from both a trait package and an insecticide. Some of them, the insecticide is really the best and only solution. In some cases, even the genetics combined with a crop protection product are the ideal output. For example, in breeding we breed for nematode tolerance in our soybeans for Brazil, but that control isn't complete. Having an nematicide provides a really more comprehensive solution for the grower, so for the grower the best solution is to bring both of them together. We're going to see more and more of this co-development of products that are further optimised for each individual situation and condition that growers encounter.

If we go back all the way to the very beginning of the pipeline I think you're going to see and ultimately over the years we're going to be able to talk about where we are developing products that from the very beginning are designed to work together. The best example that we use today to illustrate this is the concept of a trait that is being developed at the same time we're developing a weed control chemistry. Actually, that is one of the first conversations our team is already having, which is our team that is working on new chemistries and weed control are already talking to our teams that are developing traits, and they're coming up with concepts and ideas of early stage chemistries that we are looking at to see if it makes sense, and we have the potential to develop a trait for that chemistry. So more to come in this space, but really exciting for us to see; all of that all ultimately being designed to bring that full package of solutions to the grower, reduce that variability, and create more potential and sustainability for each individual customer.

So again, I hope I illustrated to you that we've got a tremendous pipeline. We are the clear leader, not only in terms of our commercial reach, our R&D size and scale, but just the internal capabilities that we have in each of those pipelines and how we're going to bring all those platforms together to really provide a tailored solution for our customer growers.

With that I will stop, and we'll switch over to Q&A. Jürgen and Ben will be here from IR; they've got the mics, and Jim Swanson, who's my colleague in our IT and Digital Transformation Lead for Crop Science, will join me for the Q&A, so thank you.

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