Towards a Bio-Based Future

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The great agronomist Norman Borlaug once said, "There are no miracles in agricultural production."

Of course, I don't have to tell you that. Feeding the world's growing population is not something that will happen just because we want it to happen. We have to work at it.

Global cereal production has doubled in the past 40 years, mainly from the increased yields resulting from greater inputs of water, pesticides, new crop strains and extensive fertilizer use. The latter alone has increased 600%.

The challenge we face looking forward to 2050 is not unlike that challenge. We have 40 years in which we need to double agricultural output, but we have to do it sustainably with the same amount of land, less water and reduced inputs.

To accomplish this will require a major effort. We must broaden our current perspective which focuses mostly on crop development, and transform to a much clearer focus on soils and fertilizer. Because no matter how sophisticated crops we have engineered or how well we manage crop epidemies, it will be not be enough; as Mr. Borlaug stated in a response to the challenge of feeding a global population of 6 billion people: "Without chemical fertilizer, forget it. The game is over."

The game is not over. But we have to reframe the way we think about fertilizing - from being about using too much or too little – *into a question of increasing the efficiency of fertilizer.*

Today, I want to talk about one specific and very fundamental challenge, which in my opinion is overlooked: Within only a couple of generations, we may be living in a world where phosphate demand will exceed supply. As phosphate is the fuel of fertilizer, this could be one of the greatest challenges to future agriculture.

(THE CHALLENGE)

Traditionally, we've fueled our crops the same way we fuel our cars: we extract raw materials from the earth. When we need gasoline, we drill for oil. When we need fertilizer, we mine phosphate. When one mine is depleted, we mine somewhere else.

But phosphate, like oil, is a finite resource. And while oil is scarce, phosphate is geographically much scarcer. The remaining reserves will be increasingly expensive to process, as the quality according to the

industry is declining while energy prices most likely will continue to increase. Last year the International Fertilizer Development Centre reported that global phosphate reserves will last more than 300 years -- at current consumption levels. That is a fairly long time. But please note: If consumption increases just 1% per year, we will only have half of that time left.

Of course even 150 years is a long time. But perhaps the key question is not when we run out. We will be in a crisis well before then. Because unlike oil, there's no such thing as an alternative source – phosphate is our only source.

What we have here is an opportunity to act.

Fertilizer is already the single biggest input cost for crop growers. As demand for phosphate continues to grow, prices are likely to continue to rise, become more volatile, with sudden spikes, just as we have seen over the last decade. When this happens, food retailers will try to keep prices down by putting the squeeze on farmers. But eventually, the rising cost of phosphate will be passed on to consumers.

With all the other challenges we face in agriculture, from land use to water to infrastructure, this might seem a small issue with many years' time to respond. But we're already seeing how destructive price instability is. Phosphate prices have increased 50% year on year since the 2008 price spike of 500% that shocked world farmers and prevented many from fertilizing.

(SOLUTIONS)

Here's the bit of good news: Biotechnology can provide a piece of the puzzle.

Because the world isn't actually running out of phosphate… we're <u>wasting</u> phosphate. And here is why this is good news:

About 80 percent of the phosphate in animal feed is trapped in molecules the animals can't digest, and it ends up in the manure. Plants have the same problem: around 80 percent of the phosphate in fertilizer quickly binds to compounds in the soil and becomes unavailable before the plant can get to it.

To make matters worse from an environmental point of view, the wasted phosphate – actually 10 percent of what we globally mine every year – leaches into our waterways, where it nourishes large populations of algae, which use up the oxygen in the water over a wide area, and kill the fish. Such pollution has already created more than 400 marine "dead zones" around the world increasing 10% every year, according to the United Nations Environmental Program's 2011 Year Book.

So wasting phosphate is a huge problem in both the short term and long term. Which is why asking the same old question – "How can we mine more phosphate?"- won't provide a solution. In a very literal sense, we've dug ourselves into a hole, and digging ourselves out is not an option.

At Novozymes, we work with farmers every day, and we know firsthand how innovative and sustainable agriculture can be. And we believe we know what form the next generation of solutions will take. They will be biology-based.

We're already seeing the power of bio-based solutions to conserve phosphate.

As I mentioned before, feed contains a lot of phosphate, but most of it is unavailable for animals to digest and ends up in manure and polluting downstream waterways. The farmer knows this, and has to add extra feed phosphate to make up for the waste. But if instead, he uses phytase enzymes, they will make the natural phosphate available for the animal. In this case, the natural phosphate is enough and the farmer needs to add only a very small amount of extra phosphate to the feed.

A number of farmers are already making this choice. But of course, reducing the amount of phosphate in animal feed addresses only a very small part of the overall problem. 90% of the phosphate used in agriculture goes into the soil as fertilizer. So the biotech industry is working on developing solutions to use phosphate more efficiently in the soil as well as in animals.

One way we've done this is to take the same principle behind phytase and apply it to plants—a fungus called "phosphate solubilizing inoculants." Phosphate inoculants break the bonds that bind phosphorous in the soil. This allows more phosphorous to end up in the roots. Farmers using phosphate inoculants can reduce up to 40% of the recommended phosphate fertilizer while increasing yields an average of 7% depending on crop and soil type.

This microbial solution has gained interest around the world as a means to improve fertility in soils with poor phosphate availability and today the use of this fungus has been taken up in North America, Latin America, Australia, India, Vietnam and Ukraine with more than 600 farmer split field trials. If microbial based fertilizer was adopted on a truly global scale, it could be an important tool to help stabilize phosphate prices and reduce farmers' exposure to risk.

But I'd like to take this one step further; I would like to see the world turn phosphate into a renewable resource.

In the same way that ecosystems operate, phosphate could become part of a circular production loop. Novozymes is looking at new ways to collect waste—manure and sludge—and extract the phosphate in a clean, distributable form that is highly available to plants. If we can develop these technologies and bring them to scale, we could reclaim vast amounts of phosphate that would otherwise be washed downstream.

This sort of "closed loop" is the hallmark of a renewable-based society.

Consider the effect this could have on some of the grave challenges I mentioned earlier:

- One challenge was production. Closing the phosphate loop would, as I've described, help us grow more food, now and in the future.

- Another challenge is preventing future price spikes and shortages in phosphate supplies. Phosphate prices rose 500% during the 2008 food price crisis. Closing the phosphate loop could stabilize the supply of phosphate and with it, fertilizer prices.

- A third challenge is protecting the environment. Closing the phosphate loop would keep a lot of phosphate out of our water, reducing pollution and giving "dead zones" a chance to recover.

That's the kind of society we envision. A society where we can sustainably increase production. Where we don't just postpone consequences, but solve problems.

(CALL TO ACTION)

But we need to act now.

Lets us not wait for the pressure on this resource to build and the price fluctuations intensify – let's not wait for the demand for a limited phosphate resource to become a phosphate crisis.

We can make sustainable choices, but only if we are willing to change the way we think, and the way we operate.

In the end, the answer to these problems lies with the farmers, just as Dr. Borlaug said. Change will happen from the ground up—literally.

We have to give farmers the tools they need to grow the food, feed and biomass we need. We must implement solutions on a scale, and at a speed, that no one sector can provide. That's why it's so important for a broad alliance, including agricultural suppliers, individual farmers and internationally recognized organizations like the FAO, IFDC, and the World Bank, all to get involved in solving this problem.

So far, efforts to optimize fertilization have focused on more precise timing, placement of fertilizer and no-till cultivation. Now it is time to focus on what biotechnology can do to make fertilizers more effective, particularly through the use of microbial-based solutions. Governments need to invest in managing phosphate. And leaders like you – I hope you will speak up and let people know that this is not only possible, but essential… and completely doable.

Collectively, globally, we need to provide incentives for farmers to use technologies like phytase and inoculants. We need to support research and development of how to transform the manure and the sludge from a waste stream into a value stream; making the phosphate available for plant uptake in a form that can be globally distributed to where it is needed.

Most importantly, we all must work to make sure the early-warning signs that we are receiving now aren't ignored. When we think about yields, climate change and global markets, we must include phosphate in these discussions.

If we address the challenges before us —and do so together, proactively — I am confident that we can not only avoid a crisis, but achieve something even larger. The biotech work in agriculture will lead the way in showing us what is also possible in other areas, from producing energy to protecting the natural

environment. We will have a taken a step towards creating a more sustainable, and more truly bio-based society in our lifetimes. This is necessary if 9 billion of us are to share this planet and live well.

I invite you, even urge you, to join us and a growing number of other companies in this essential work.

Thank you. # # #