

Feeding the World: A Legacy of William Henry Hatch

Gale A. Buchanan dedicated his life to agriculture and agriculture research. On November 14, 2016, he delivered, "Feeding the World: A Legacy of William Henry Hatch." This William Henry Hatch Memorial Lecture was presented at the Association of Public and Land-Grant Universities in Austin, Texas.

Thank you for your kind introduction. It is a very special honor to be invited to present the 2016 William Henry Hatch Memorial Lecture. I am deeply humbled and greatly appreciative of this opportunity.

For someone who has spent their entire life in agriculture from the farm, to a land-grant agricultural education, to an agricultural research and administration career, then retirement and back to the farm, I can think of no greater honor. In one way or another, my entire life has been tied to William Henry Hatch. For an old experiment station director, it doesn't get any better than this.

Again, thank you for this opportunity. William Henry Hatch was born in Kentucky in 1833, studied law and was admitted to the bar in 1854. After practicing law a few years and then serving in the Confederate army, he was elected as a Democrat to the 46th Congress representing the solid agricultural First Congressional District of Missouri. He won eight successive terms. Hatch was a long-serving chairman of the Committee on Agriculture.

I suspect that if Congressman Hatch was around today, he would be 173 years old and probably scoff at my attributing "Feeding the World" as one of his legacies. But he did what great elected officials do. He listened to the people and put their concern into legislation that had far-reaching implications for our society. He was probably aware that several states had already created some type of experiment station. For his vision, foresight and effort, this lecture is named in his honor.

The language of the Hatch Act is only a few pages in length. Quite a contrast to some of today's legislation such as the 2700 pages of the Affordable Care Act, along with over 30,000 pages of implementing rules and regulations. While I'm sure most of you know I'm talking about the Hatch Act of 1887, it's not to be confused with the Hatch Act of 1939. That act limited public employers from engaging in political activity.

For the beginning of formal agricultural research, I use the initiation of The Rothamsted Experimental Station in England in 1843. Even without the internet, air travel, or the transatlantic telegraph the idea for research crossed the Atlantic very quickly. In fact, by the time of the passage of Congressman Hatch's bill, 14 states had some form of experiment station. About the only things these stations had in common were their commitment to improving agriculture and extremely poor funding base.

There were many individuals who made the case for such legislation authored by Congressman Hatch. Meetings of agricultural leaders in 1871 and 1882 were pivotal in establishing the need for seeking better ways of farming. Seaman Knapp from Iowa was one of the articulate spokesmen for such legislation. There was some legislative support of this revolutionary idea by Congressman Carpenter of Iowa and Congressman Cullen of Illinois.

In the next congressional session, with Carpenter and Cullen no longer in Congress, it was left to the chair of the Agricultural Committee, Congressman Hatch, to draft legislation that among other things:

1. Recognized the importance of agricultural research
2. Provided direct support of agricultural research
3. Provided for the establishment of an agricultural experiment station in connection with the colleges established in the several States under the provisions of the Morrill Act of 1862.

While Congressman Hatch deserves the recognition and credit we give him, I'm sure he would quickly give credit to those many individuals who championed the idea for agricultural research. In the next few minutes I want to provide the rationale for Congressman Hatch's legacy, "Feeding the World." I'll start with a question, "What are the challenges for agriculture in feeding the world?" I should point out that much of my lecture is based on my recently published book, "Feeding the World: Agricultural Research in the Twenty-First Century."

I'd like for someone far more learned than I to respond to this question. One of those is Nobel Laureate Norman Borlaug. In his last article before his death in 2010, he answers this question well. He said in a Council for Agricultural Science and Technology paper, "Agricultural Production Strategies for the Future," the following: "In the next 50 years we are going to have to produce more food than we have in the last 10,000 years, and that is a daunting task. I therefore have called for a 'Second Green Revolution'." It is abundantly clear that the challenges facing this planet are real. The thesis offered by Thomas Malthus that population, if unchecked, increases geometrically while food increases arithmetically indicates the challenge for agriculture. Fortunately, Malthus' concern has failed to materialize for the past 200 years for one primary reason — new innovation and technology that supports agriculture. This has been made possible by agricultural research.

The challenge for agriculture is based on several uncontested facts. First, is a growing population on the planet. At the dawn of formal agriculture, the world population was estimated to be between one and five million. This was while the human species existed as hunters and gatherers.

In the short span of 10,000-12,000 years, as agriculture evolved and improved, man became more sedentary. World population grew to about 200 million by year 1 A.D., reaching one billion in 1804 and four billion in 1974. Today's world population is almost 7.5 billion. We are growing at over 100,000 each day — over 70,000,000 so far this year. In 1840, about the time of the beginning of formal agricultural research, the population of the planet was about 1.4 billion. In the 175 years since, the planet has gained 6.0 billion people. It is not fortuitous that the

growth in world population coincides almost precisely with the emergence of agricultural research.

There are other challenges. Just about everybody wants more. All of the human beings who inhabit this planet want and deserve adequate food. Even those who have adequate caloric intake want greater diversity and improved quality with more animal products, fruits and vegetables in their diet.

Then there are other uncontested facts, including unknowns such as the impact of climate change, world order (political instability) in many countries, and availability of production resources such as plant nutrients, water and energy which are required for food production.

However, the key to “Feeding the World” is agricultural research. Agricultural economists have done a beautiful job of showing the relationship of research to agricultural productivity. They have developed a concept called total factor productivity (TFP) in U.S. agriculture since 1948. In their assessment, they take into account all of a commodity outputs and resource inputs employed in production of that commodity.

Their analysis shows that the sum total of land, labor and capital inputs employed in agriculture has hardly changed since 1948; however, by 2009 the output of crops and livestock had risen over two and a half times. That increase in output, then, is almost entirely due to knowledge-based productivity gains. It is often said, “A picture is worth a thousand words.” Well, I want to show you a picture worth 10,000 words. Maybe an infinite number of words.

This chart shows how TFP and output closely parallel each other. The top curve (output) and the TFP curve closely parallel each other. Note the input curve. It is essentially flat or slightly lower in the past few years. The real challenge is to ensure these curves continue to reflect this relationship in the future. Agricultural research is essential in increasing output while holding inputs constant. This is, indeed, a challenge. But it is possible – if we maintain robust support of agricultural research.

What this really illustrates is that virtually all of the growth in U.S. agricultural output in the past 5 decades can be accounted for by improvements in technology, farming practices, and other factors that have enabled farmers to use their time and resources more efficiently. The key factors in driving this increase over the long run has been the investment in agricultural research.

I would like to emphasize that both public as well as privately supported research contributes to this success. In fact, today, in the U.S., industry provides greater support for agricultural research than does public institutions. The key question and my greatest concern today is, “How to continue proving Malthus wrong by increasing agricultural output with a constant level, or perhaps an even lower level, of inputs in the future?” Our challenge is even greater because of positive developments in human medicine. Can you imagine learning to manage or cure all human diseases in our children’s lifetime? I can’t, but Facebook founder and CEO, Mark Zuckerberg, and his wife can. They are pledging much of their fortune to that goal. While this is a fantastic and commendable goal, just think how success of this effort will add to the food

challenge. The challenge of “food security for all” immediately calls into question, “Who has the responsibility?”

Is it our politicians? Hardly, they have enough challenges just “managing the store.” And doing what it takes to keep getting re-elected so they can remain a politician. Is it industry? Hardly, unless it can fit into the quarterly bottom line, they are off the hook.

My short answer is we all bear some responsibility. I’d like to mention a few of these groups. Agricultural Scientists.

The first category is agricultural scientists. While I don’t want to be critical of my research colleagues, often I think we dream too small. Agricultural scientists must be the ones who challenge the status quo and push the envelope. I’m well-aware of the challenge of young, research scientists. Newly appointed, whether industry, government or university, they must “hit the ground running” or else they will be required to seek employment in another line of work.

I quickly admit that addressing incremental research challenges has collectively contributed to a very successful agriculture in this country. But I think it’s time to revise our playbook and devote more effort to addressing game-changing problems — I call grand challenges — in agriculture while maintaining high quality, traditional applied research programs.

There are many positive signs that we are moving in the right direction. The September 16 issue of *Science* offers several challenging ideas for future agricultural research. Some of these visionary ideas and challenges are both interesting and quite exciting.

In an editorial in the Oct 14 issue of *Science* was a discussion regarding the challenge and importance of basic research to success in U.S. industry. Of course, a similar argument could certainly be made for agriculture. I’m often reminded of a statement by Wilbur O. Atwater, the nation’s first agricultural experiment station director, who said, “It has been felt from the first that more abstract scientific investigations would afford not only the proper but also the most widely and permanently useful work of an Agricultural Experiment Station.” The truth is, we must have strong applied research programs as well as creative and innovative basic research — if we expect to meet the challenge of feeding the world.

Here are a few grand challenges that if successfully addressed would bring about a new paradigm in agricultural productivity:

1. Improving soil quality (not just protecting what we have, but making what we have better);
2. Improving energy efficiency in agriculture (We have already done a lot e.g. no till, but many opportunities remain);
3. Introducing nitrogen fixation in non-legumes (Just imagine zeroing out nitrogen costs for grass crops. Our air is over 78% nitrogen. Most plants just can’t use it.);
4. Enabling important crop plants to utilize the C₄ photosynthesis pathway (One can argue that photosynthesis is a fantastic process — but C₄ is better);

5. Developing crop plants that have greater water, nitrogen and other nutrient efficiencies. (We know there is great diversity throughout the plant kingdom. We need to incorporate more of that efficiency into crop plants.);
6. Developing crop plants that are productive in an increasingly unpredictable climate and thrive under both biotic and abiotic condition;
7. Eliminating disease and improving quality of food animals. (While we are eliminating diseases of humans, we must do the same in our food animals. It has been done. For example, rinderpest or cattle plague in cattle has been eradicated!);
8. Incorporating the process of apomixis in crop plants; (just imagine collecting seed from a hybrid that bred true!);
9. Develop more efficient processes for conversion of agricultural products into more usable forms (converting biomass into a usable energy form);
10. Developing plants with enhanced health benefits. (Perhaps the next major paradigm change – marrying medicine and agriculture.) There are many other such challenges.

Agriculture scientists need to be free to tackle the big questions, to take risks, to occasionally fail. The drug companies have repeatedly hyped in their advertising that the reason drugs are so expensive is that in solving health problems they have to repeatedly try and fail in coming up with new formulations, new approaches to therapy. They need to be rewarded for the huge risks they take. Shouldn't feeding people be similar? Legislative Bodies

Another group that bears some responsibility is congressional delegations. They made possible the Agricultural Experiment Station System we enjoy today. While the Hatch Act of 1887 has served us well for the past 130 years, maybe it's time for an overhaul with new legislation that understands and better appreciates the achievements of the past, and recognizes the challenges of the present, and focuses on harnessing scientific, technological, and social advances for the future. Consumers.

One other category of individuals who have a responsibility for ensuring a secure food future is consumers. Unfortunately, the disconnect between agricultural production and food seems to be growing.

Unfortunately we have more consumers that are more concerned about square footage of sleeping quarters for laying hens and in exercise space for gestating sows than in developing a realistic understanding and appreciation of what it takes to ensure food security.

I think we must recognize that consumers are not one large monolithic block of people — rather we need to engage individual groups within that block such as business leaders, community leaders, parents, various special interest groups, to become involved.

We should be working with specific sub groups to become more knowledgeable about science, in general, and the science of agriculture in particular. Agricultural scientists should be more transparent in the technology of food production.

While there are some excellent articles about food in the popular media, unfortunately,

consumers are often bombarded with articles such as one I saw recently an article by Michael Specter in the *New Yorker*, To quote: "Fertilizer should never have been allowed in agriculture. I think it's time to ban it. It's a weapon of mass destruction. Its use is like war because it came from war." Vandana Shiva Another area that is ripe with misinformation is about GMOs. The simple fact is maintaining agricultural productivity at an acceptable level without fertilizer or GMOs is about as easy as un-ringing a bell!

Future food security will be determined by new innovative information knowledge and technology which can be gained only through research. The Way Forward.

I am concerned about our way forward. In this country and many others, we have enjoyed a historical abundance of plenty so why expect that to change? While this is comforting, we must not become too complacent.

There seems to be a lessening of appreciation and understanding of the importance of agriculture and what it takes to assure our food supply. If the world stays the same, there is perhaps some reason for hope. Unfortunately, there are clear indications the world is not going to stay the same. We are unable to predict with much certainty what natural disasters will beset humanity in the future or what changes may occur.

In addition to natural disasters, I'm equally concerned about the possibility of a man-made catastrophe, such as war. War has multiple effects including mass migration, mass starvation, disruption of markets as well as major utilization of resources for armaments and other military assets. If much of your population is fighting — they can't be engaged in producing food. With higher populations, there is far less room for flexibility and room for error.

However, one of my greatest concerns is expressed in an article in *Nature* by Phillip Pardey and his colleagues. They note the slower growth in public spending for ag research by the world's richest countries. If that is not bad enough, they further point out that the regions of the world that are experiencing the highest rate of population growth have the lowest investment in ag research.

For a secure and peaceful planet, all people must have a reasonable level of food security. We are fortunate to live in a country with an abundant food supply. All people on this planet are not so lucky. It is estimated that almost a billion people do not have adequate food. There are many more who do not receive an adequate diet including proteins, fats and minerals for normal development.

Our system has been phenomenally successful with even meager funding for agricultural research. However, to meet the challenges that lie ahead, agricultural research must be better supported. For that to occur, I think we must strengthen our research system. In this figure, we see general funding for several federal agencies over the past two decades. Agriculture has clearly fared poorly when compared with some other research agencies, particularly NSF and NIH.

To strengthen our agricultural research system, I would like to propose a few suggestions:

A. Identify the research challenges that, if accomplished, would bring about a new paradigm in agricultural productivity. I've identified a few of such challenges, but our best and brightest should help identify other areas that hold great promise that, if solved, would bring about a new paradigm in agricultural productivity.

B. Encourage more visionary, high-risk research. I think we should engage in more high-risk research where the probability of success is much lower, but the potential payoff is far greater. First, we have to identify the Higgs boson of agriculture. Our recognition and reward system must recognize this fact.

Are we investing adequately in how we can employ principles and techniques of nanotechnology, informatics, and artificial intelligence in agriculture?

I don't think we are even investing adequately in genomics and classical plant and animal breeding. Our current reward system is not conducive to "failure" in research. We need to change such that research scientists are properly rewarded for engaging in high risk research that sometimes does not provide positive results. *C. Develop more effective international collaboration.* All nations have at least one thing in common — they all require adequate food. This is one area where all nations could, or should, cooperate. We have made remarkable progress in this area. Both USDA and our universities have many, many international relationships.

I'd like to mention just one area. The present USDA Chief Scientist and Under Secretary of Agriculture for Research, Education and Economics, the Honorable Catherine Woteki, has been successful in making agricultural research a part of the G-20 Summit.

To foster intellectual collaboration she has identified six strategic platforms to achieve sustainable food security. Among these are:

1. Open access to scholarly publications
2. Open access to germplasm collections
3. Open access to genomic and genetic data
4. Accelerated technology transfer
5. Improved global agricultural statistics
6. Establishment of regular coordination of the world's chief agricultural scientists on agricultural research and development in conjunction with the G20 Summit.

This visionary effort represents a great start in the right direction.

D. Improve quality of leadership of those responsible for agricultural research programs. This might be the most important idea yet. We have made excellent progress in this area, starting with the ESCOP Leadership Program and National Leadership Development Program. Today we have LEAD-21, and FSLI. In addition, there are emerging leadership programs in many of our

universities.

E. Recruit future scientists that are among the best and brightest young people. We pretty much take whoever comes along. I see little real recruiting of the best and brightest students for agricultural programs. Why not take advantage of our tremendous 4H and FFA programs in identifying some of these “best and brightest” students in high school. For once, why don’t we emulate athletics?

F. Strengthen the funding base for agricultural research. Yes, funding is critical but recall my earlier point — incremental research will lead to incremental increase in funding. I think we must become more visionary and engage in more high-risk research in order to justify greater support.

G. Create a “stand-alone” agricultural research agency of the U.S. government. I’ve thought a lot about this one. I think the rationale for a stand-alone agricultural research agency has equal merit to NIH. A small step was taken in the 2008 Farm Bill creating a Chief Scientist for USDA embedded in the Under Secretary for REE position.

These are just a very few of my ideas. I mention several others in my book. I’m confident that there are many other great ideas for improving our system.

My final assessment is that the key to feeding the world is leadership. With a challenge so great, one hopes for the emergence of one or more leaders who will be able to articulate the role of agricultural research in food security and the well-being of our civilization such that its importance and relevance are universally recognized, appreciated and supported. With that accomplished, our future becomes a bit more secure. In conclusion, I’d like to summarize the facts I’ve presented:

1. Success of agriculture is necessary for feeding the world.
2. Agricultural research makes possible the success of agriculture.
3. The experiment station system contributes greatly to the success of agricultural research.
4. Legislation authored by Congressman Hatch created the experiment station system.

Therefore, feeding the world is a legacy of Congressman William Henry Hatch. I rest my case. Thank you.