Agricultural Biotechnology Support Project II, South Asia

Supporting agricultural development through biotechnology

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About ABSPII

The developing world can benefit from advances in biotechnology, but much needs to be done to make bio-engineered products available in forms that farmers can use. The Agricultural Biotechnology Support Project II (ABSPII) believes that farmers and consumers worldwide should have the opportunity to make informed choices about using bio-engineered products. ABSPII focuses on the safe and effective development and commercialization of bio-engineered crops as a complement to traditional and organic agricultural approaches in developing countries. The project helps boost food security, economic growth, nutrition and environmental quality in East and West Africa, Indonesia, India, Bangladesh and Philippines. Funded by the United States Agency for International Development (USAID) and led by Cornell University, ABSPII is a consortium of public and private sector institutions.

The consortium develops innovative, pragmatic solutions, building on the successes of the Agricultural Biotechnology Support Project (ABSP) that was led for a decade by Michigan State University.

In South Asia (India and Bangladesh), ABSPII supports development of expertise in the areas of research, policy development, licensing and outreach to help reduce poverty and hunger through agricultural biotechnology. Current initiatives relate to development of Tobacco Streak Virus Resistant (TSVR) groundnut, Late Blight Resistant (LBR) potato, Fruit and Shoot Borer Resistant (FSBR) eggplant, Drought and Salinity Tolerant (DST) rice.

Message from K. Vijayaraghavan

Regional Co-ordinator, ABSPII, South Asia

Dr. Borlaug is no longer among us in physical form, but he has left a deep legacy for Scientists in the world to fight hunger and poverty applying advancements in Science. Till his last day, he has never rested and continued to harness the power of science for addressing key issues impacting crop losses. My colleagues and I had the immense fortune to be associated in the recent initiative to mitigate the Ug99 and other Rusts in wheat crop across key wheat growing regions that was initiated by him. He indicated that “Rust never sleeps”.

During his last visit to India, he was thrilled to see the Bt eggplant in the green houses of one of the partner institutions. He advocated genetic modification to mitigate world hunger indicating that growing organic food all over the earth would not address the hunger of a fraction of the world population.

This issue of the ABSPII South Asia Newletter is dedicated to the everlasting legacy of this great scientist and even greater human being.

At this time, it is time to renew our commitment to high quality science and development efforts to find solutions for enhancing global food productivity and for mitigating crop losses due to pests and pathogens. This is the greatest contribution one can make to this noble soul that has departed this world.

ABSPII partners witnessed great progress in advancing all the research programs during the last six months as some of them are getting closer to the milestone of reaching farmers. Our efforts to strengthen the seed multiplication and seed delivery capacity within public research partners will continue to ensure that the resource constrained farmers secure their seeds. This will help to ensure greater socio economic gains from research investment and provide equitable opportunity for farmers based in remote villages to access quality seed.

Feature

Norman Borlaug: Passion, Persistence, and Persuasion[1]

Robert W. Herdt, International Professor of Applied Economics and Management; Adjunct, Department of Applied Economics and Management, Cornell University; former Director of Agricultural Sciences and Vice President, The Rockefeller Foundation.

It is a privilege to contribute information about the life and work of Norman Borlaug, one of the truly great Minnesota Plant Pathology Alumni and outstanding figures of our day.

Norman Borlaug received the Nobel Prize in 1970, thirty-seven years ago, about 25 years after he began working to increase food production in Mexico. So he received the Prize at the mid-point of his career. Before then and since then he has endured much and accomplished much, and he continues, working every day, traveling around the world, pursuing his mission, inspiring each of us by his very presence.

At 93 years of age, Norm is still going strong, working uncounted hours in Texas, in Mexico, and in Africa[2]. His life is a story of hard work, determination, persuasion, persistence and passionate dedication to helping farmers produce more abundant food for others and better lives for themselves. As Newsweek recently reported (July 20, 2007), only five people have been awarded the Nobel Peace Prize, the Presidential Medal of Freedom and the Congressional Gold Medal - Mother Theresa, Nelson Mandela, Martin Luther King, Jr., Elie Wiesel and Norman Borlaug. Norm shares many characteristics with the other four: self-sacrifice, dedication, patience, vision, and compassion. And like the others, as anyone who has heard him speak knows, Norm is passionate about his convictions, persistent in going after his goals, and a master persuader articulating those goals.

Early Years

Born at the beginning of the First World War, Norman learned his early lessons at a one room school in Howard County, Iowa. Growing up on the family farm, he came to know the value of hard work and clear goals. More importantly, in his own words, he came "to know right from wrong from his parents, grandparents and neighbours."

Norman was a teenager during the Great Depression, and one can only imagine the courage and determination it took for him to leave the farm during the depths of that depression and come here to the University of Minnesota where he would earn his Bachelor's, Master's and Doctoral degrees.

It must have been during his formative years at the University that he came to recognize the power of science to address practical problems of farmers. After a brief time with the Forest Service, he decided to continue his education as a graduate student under one of the giants in plant pathology, Professor E.C. Stakman. The influence Stakman had on Norman Borlaug is hard to overstate. Especially memorable was a 1938 lecture where Stakman characterized wheat rust as "a shifty, changing, constantly evolving enemy." That view of wheat rust has stayed with Borlaug to this day.

A Lifetime of Service

After obtaining his doctoral degree with Professor Stakman, Norman took a job as a microbiologist with DuPont, but after a few years had the opportunity to join one of the first international agricultural development assistance programs, the Rockefeller Foundation program in Mexico.

With the encouragement of Vice-President Henry Wallace, in 1940 the Foundation entered discussions with the Mexican Government and sent three distinguished professionals to review their agricultural situation. Professor Stakman with Professors Richard Bradfield of Cornell and Paul Manglesdorf of Harvard spent more than two months roaming over thousands miles of highways and byways in sixteen of Mexico's thirty-three states, seeking to understand the situation and how the Foundation might help. The essence of their recommendation was that the Foundation should send a team of scientists to work with the Mexican agricultural ministry to breed better plant varieties, improve soil and crop management and increase livestock productivity. J. George Harrar, another University of Minnesota plant pathologist, who was later to become the Foundation's President, was selected to head the team, and Norman Borlaug was invited to join him. Thus Norman Borlaug began the first phase of his life's work.

1944 through 1960 were dedicated to helping Mexico increase its food production. The first years were learning by doing. Borlaug was the team's pathologist and so had responsibility for all the diseases attacking all the crops - with emphasis on dry beans and corn. But in reality Norm did whatever needed doing -- insect control, plot layout, planting, and recruiting helpers.

Looking back on it, Borlaug recalls that Harrar "came up with the ideal intellectual platform for launching an attack on hunger. He gave us the freedom to make our own decisions and to exercise our fullest capacities without interference. He managed the program based on four principles:

1.This article originally appeared in the *Aurora Sporealis: The Alumni News Magazine of the Department of Plant Pathology*, University of Minnesota, 2007: pp.24-29 and is reprinted here with permission. All issues of Aurora Sporealis are available in the University of Minnesota Libraries' Digital Conservancy. http://conservancy.umn.edu/handle/923

2.This talk was originally delivered as an Evening Speech during the Department of Plant Pathology Centennial Celebration at the University of Minnesota on Legacy Day, September 18, 2007.

- To hire the best people for the tasks;
- To provide them a lifetime commitment;
- To shield them from distractions; and
- To share all research results freely with whomever could use them."

Borlaug recalls, "We were to help Mexico solve its own food problems. In other words, alongside our own work we were to train local scientists and ease them into our jobs. Moreover, we were to be neither consultants nor advisors, but working scientists getting our hands and boots dirty, and demonstrating by our own field results what could be done."

Those principles and a determination to work our way out of the job and make way for those with the continuing responsibility for it characterized the Rockefeller Foundation's agricultural program for many decades.

But in the process Borlaug had to fight some aspects of Mexican culture, in particular the conviction that scientists were above hand labour or getting dirty. He was told by one of his colleagues in the early days, "Dr. Borlaug, we don't do these things in Mexico. That's why we have peons. All you've got to do is draw up the plans and take them to the foreman and let them do it."

Borlaug lost his temper (it wasn't the last time). He yelled back "That's why the farmers disrespect you. If you don't know how to do something yourself, how can you possibly advise them? If the peons give you false information, you wouldn't even know. No, this has to change. Until we master our own efforts, we will go nowhere in this project."

In 1944 wheat was Mexico's second most important food crop, and half of it was being imported, at an annual cost of $21 million. Average yields were 11 bushels to the acre, about half the US level, but subject to enormous fluctuations caused by epidemics of wheat rust. It was an obvious target for the Harrar team, and George himself organized the first year's work on wheat.

In Borlaug's boyhood the Iowa home farm had never grown wheat, and Norman's doctoral thesis had been on flax. So when George Harrar asked Norm to take over the wheat program after the first year, he had little background to draw on. But that didn't stop him from taking up the challenge. And so he began his lifelong, persistent attack on wheat rust, that shifty, ever-changing enemy fingered by Professor Stakman.

Norm and his small team began by making crosses among five established Mexican varieties and several imported ones. The resulting thirty-eight combinations, by some stroke of luck gave promising results from the beginning, and four selections were later released as varieties, resulting in notable increases in Mexico's wheat production by the late 1940s.

But the potential for disaster remained always in Borlaug's mind. That constantly changing enemy, wheat rust, was at bay but not defeated. In the years to come he was to make two innovations that had tremendous payoff. Most plant breeders made a few crosses or a few dozen crosses each season. The many individual plants that resulted each were observed throughout the growing season and seeds from the best individuals harvested and planted the next year, with more selections made, and so forth for eight to ten years.

Recognizing that each individual plant is potentially valuable, the general practice was to keep most and advance their progeny to the next generation. But the number of individuals rapidly increases and the work of observation can become overwhelming. As Borlaug says, "This hit-or-miss process is time consuming and mind-warpingly tedious. There's only one chance in thousands of ever finding what you want, and actually no guarantee of success at all."

Success in breeding wheat means keeping ahead of the ever evolving rust organism. Failure means disaster for farmers, nations, and even in an extreme case, the whole world. Borlaug became convinced that only by making thousands of crosses from wheat gathered from all around the world would he be able to raise the probability of finding the right combination to a high enough level. So he began to make many more crosses than any breeder had until that time. That meant a tremendous increase in the fieldwork of examining and scoring the progeny, imposing tougher criteria and discarding a higher fraction of plants. This approach, high volume crossing, gave a much higher overall probability of success.

But it still required eight to ten years to get a variety and Norm looked for a way to grow two crops a year in order to cut down on that time. A possible place was the Yaqui Valley in Sonora, 1200 miles to the north, where irrigated wheat was normally planted in the fall. But the wheat program, like the other parts of the Foundation's effort, was focused in Toluca, not far from Mexico City, where most farmers were exceedingly poor and the climate was very different from Sonora. Borlaug proposed establishing an "off-season" facility in Sonora but that idea didn't sit well with Harrar and failed to gain his approval. Getting George to change his mind was to test Norm's passion, persistence, and powers of persuasion. Even so, it took the good offices of Professor Stakman, who happened to be in Mexico at the time, to get Borlaug and Harrar to the point where they could agree on the plan to extend the wheat work to Sonora for a second season each year. This was the birth of "shuttle breeding."

This met Borlaug's objective of faster generation advance, but growing conditions in Sonora were a dramatic contrast with those of in Toluca and the plan went against one of the dominant plant breeding dogmas of the day -- that plants had to be designed and tested in the environments for which they were intended. Much further North and in a near-desert, as harvest time approached in the Yaqui valley temperatures soared, humidity dropped and winds were strong. Most wheat lines that had performed well in Toluca just didn't hold up in Sonora and vice versa. But a few did well in both locations. The segregating populations were shuttled back and forth over ten degrees of latitude and from near sea level to over eight thousand feet of altitude. They were exposed to different diseases, different soils, different climates and the different day lengths of winter in Sonora and summer in Toluca. The result was much more than a faster breeding process. The plants that survived and performed well were well adapted to a wide range of conditions. And, not only in Mexico. Those same varieties were to prove exceedingly well-suited to the sub-tropical wheat growing areas of India and Pakistan. Hence serendipity stepped in -- shuttle breeding was designed to accelerate the breeding process and it did, but it had another, serendipitous effect - the resulting varieties were well adapted to a wide range of conditions.

Student and Teacher

Norman's student years may have begun in Iowa in the 1920s, and formally ended with the award of his PhD degree from the University of Minnesota in 1942, but he has never ceased being a student. In addition to Professors Stakman at Minnesota, he credits many colleagues, including George Harrar, Ed Wellhausen, John Neiderhauser and Louis Roberts, with providing insights and challenges that led him to ever-greater efforts.

But perhaps his greatest teachers were the wheat plants to which he devoted uncounted hours. As he says, he learned "to tell the status of a wheat plant from its look, manner of growth, feel, movement, and level of growth. Wheat itself was becoming a person. Moreover wheat was the best teacher about wheat." He began to see that different wheats had different "personalities." He could tell them apart at a glance, or "even by the rustle of the wind through their ripening heads." Like many other pioneering plant scientists including Mendel and McClintock, Borlaug's advances were based on careful observations made during hours and hours of devoted work.

The untold story of Norman Borlaug's life is, however, his career as a teacher. In the very first days of his assignment to the Rockefeller Foundation's program in Mexico he encouraged young Mexican technicians to learn the secrets of plant breeding -- crossing and selection -- the critical steps that most plant breeders kept to themselves. Throughout the Mexico period he gave young people the opportunity and responsibilities to learn.

But learning from Borlaug wasn't easy, and didn't take place in an air-conditioned classroom. It involved preparing land, planting seeds, taking observations and making notes, making crosses, making more observations, harvesting, keeping records, and doing analyses. And, after the invention of shuttle breeding, the process was a year-round effort, unlike most plant breeding in the United States, where the winter season is used to analyze results and plan the next year's work.

If learning from Norm was not easy, neither was being his supervisor. In those days the Annual Report of the Rockefeller Foundation was compiled from the separate reports of its officers, including those in Mexico and elsewhere. With high-volume crossing, shuttle breeding and training young scientists, Norm had limited time for paperwork. His annual reports were not always produced by the deadline and apparently one year he was particularly late. After several reminders from the responsible Director and Vice President, George Harrar, then Foundation President, sent a telegram telling Norm to get his Report in. The responding telegram was short but to the point; Norm said: "Do you want paper or do you want wheat?"

Global Agricultural Diplomat

By the late 1950s the cooperative program had made such a contribution to Mexico's food production that the Foundation concluded Borlaug had succeeded in working himself out of a job. Leadership of the national Wheat Program was turned over to Mexican scientists.

The Food and Agricultural Organization of the United Nations asked Norm to join a team of scientists to advise on its wheat work in the Middle East and North Africa, giving Norm his first trip outside the Americas. The team traveled through Algeria, Libya, Egypt, Jordan, Lebanon, Afghanistan, Pakistan and India, visiting agriculture ministries and experiment stations, observing wheat and barley research programs.

Returning to Rome, Norm reflected on the situation he had seen. Half of humanity was going to bed hungry. Many of the countries had virtually no agricultural scientists, but even those out there, in most cases weren't fired up about the food situation. They were government servants with secure jobs and little incentive to address farmer's problems.

Borlaug concluded they needed training and inspiration to address real problems. He believed that the same program of training that had helped so many young Mexican scientists to assume leadership of that country's agriculture could be used to train and motivate young scientists from the Middle East and South Asia. He took on the task of training the new candidates, not just in genetics but also in agronomy, soils, irrigation, weed control, plant pathology, entomology, cereal technology and more. After passing through a tough initial training they toiled in the fields twelve hours each day. They had to level and lay out sample plots, sow crops, apply water and fertilizer. They got a solid grounding in hunger fighting on the front lines.

As part of the training program they established the international wheat yield trials that Borlaug had recommended in his report to the FAO. The first year they sent out twenty-five lines of wheat. After that more and more people wanted to test more and more different types of wheat. In the second year fifty lines were sent out, then over one hundred. Eventually one hundred twenty five wheat lines were being sent to one hundred and fifty locations worldwide.

It seemed evident that the ideas that had been developed in Mexico could be useful throughout the developing world. In 1964, based on the model they had pioneered four years earlier at the International Rice Research Institute, the Ford and Rockefeller Foundations created the international maize and wheat research center, CIMMYT. Ed Wellhausen became its founding Director, and Borlaug became director of its wheat program.

Norman took dozens of scientists from South Asia under his wing. Some came to Mexico for formal training at CIMMYT, many more learned from his visits to Asia. With leadership from Canadian wheat breeder Glenn Anderson, the varieties created in Mexico were tested in India and Pakistan and performed astonishingly well, attracting national attention in those countries struggling to meet the demand for food from rapidly growing populations.

In 1964 and 1965 India received over 5 million tons of food aid. Many despaired that India could ever meet its food needs, but Borlaug and the Rockefeller Foundation had a different view, after seeing how well the Mexican wheat varieties performed with high-input production methods in South Asia. In the crisis year of 1965 India and Pakistan each imported over 200 tons of Mexican wheat seed for wide-scale testing. Performance was spotty, with some unprecedented high yields when fertilized and irrigated but mediocre yields in other cases. Norm's powers of persuasion led to a brave political choice by India's Minister of Agriculture to import 18 thousand tons of seed and the needed fertilizer for the next year's planting.

The imports triggered the interest of India's Planning Commission and that led to another controversy. Borlaug and Anderson backed a plan to recommend high fertilizer rates to further demonstrate maximum yields. Foundation economist David Hopper, along with Planning Commission economists, argued for a more modest fertilizer recommendation so many more farmers could benefit from the limited fertilizer being imported. Borlaug wanted the high rate and consequent high yield to overcome the "skepticism and psychological barrier of the traditionalists, peasant farmers, bureaucrats and senior scientists." Once again, Norm's passion, persistence and persuasion paid off and the high rate was recommended. A bumper crop ensued and the Green Revolution was launched.

In February of 1968 Norman made a trip to India, where, as was his practice, he visited the experimental plots at various places around the country. A new University had been established in the state of Uttar Pradesh at Pantnagar, about 5 hours drive from Delhi, where scientists had planted trials with the wheat varieties from Mexico, other international breeding lines, and crosses made by Indian scientists. Norm's visit was the occasion for a gathering of local "aggis" from around North India, including some of us from the Rockefeller Foundation New Delhi Office.

Scores of wheat varieties had been planted in small observation plots. The morning was cool but bright, one of those perfect late winter days in North India when the spring heat is still weeks away. Norman arrived with the university Vice Chancellor, the head of India's wheat program, and dozens of scientists trailing along. The field was a checkerboard of short, intermediate, and tall wheat plots, some beginning to mature and others still fairly green. Most looked healthy and many promised copious yields.

Norm strode through the field barely glancing at one outstanding plot after another. He ignored the efforts of first one and then another proud scientist to explain the lineage of this or that line. Finally he found what he was looking for -- a sorry, disease-infested, disreputable plot. Pouncing on that plot he launched into a passionate warning of the potential dangers of pride and complacency. At any time, new races of wheat rust could descend on South Asia and devastate entire regions, just as that unfortunate plot had been devastated. It was the job of wheat scientist to be ever alert to that possibility, to anticipate it the "shifty, everychanging" rust enemy and have breeding lines with alternative sources of resistance ready to be quickly multiplied and made available to farmers.

None of us in attendance could forget this lesson imparted by a gifted teacher with a burning mission.

Prize Winner and Philanthropist

The story of how, one morning in the fall of 1970 Norm heard he had won the Nobel Peace Prize is recounted by Leon Hesser in his biography, The Man Who Fed the World. Typically, Norm was in the field looking at wheat plants with a group of students, one of whom remembers it slightly differently than recounted by Leon. The Nobel Prize was entirely unexpected by anyone, least of all Norm, and when Margaret Borlaug tracked him down and shouted across an irrigation ditch separating the farm road from the wheat field that he had been awarded the Nobel Peace Prize, his reply was pretty much the same expression of disbelief that most any other Iowa farm boy would have had! When more vehicles filled with reporters appeared they all realized it was true and Norm's life changed forever. He would never again be simply a scientist.

But of course, as we have seen, he had long been more than a scientist, long been a persistent persuader with a passion to use all his talents to help feed people. Now he had a bigger platform and greater credibility and used it on every occasion to preach the need to bring together science, policy and hard work to defeat world hunger.

In 1979, at age 65, Norm completed 13 years as Director of the CIMMYT wheat program and became a Senior Consultant to CIMMYT. That sounds kind of like semi-retirement, but Norman Borlaug is not the "retiring kind." He began to pursue an idea that had been germinating since that eventful day in Oslo. He petitioned the Nobel committee to establish a prize for work in agriculture but they turned the idea down. He continued to think about how to make it happen, and by 1986 he and his friend and colleague, Dr. Robert Havener, had found a sponsor and launched the World Food Prize. In 1990 the prize seemed in danger, when its original corporate sponsor was merged into another company and reneged on its sponsorship.

Borlaug and Havener began the search for a new sponsor and after many disappointments met John Ruan. Like Norm, Ruan had been born in a small town in Iowa in 1914. When his father died in 1932 Ruan had been forced to drop out of college to run the family trucking business. Now, anytime you are out on a highway in America you are likely to see one of over 20,000 trucks currently a part of the business. Borlaug and Ruan struck up a deep friendship and John Ruan became convinced of the value of the World Food Prize, and created an endowment to ensure its operation.

Today the World Food Prize is the foremost international award recognizing the achievements of people who have advanced human development by improving the quality, quantity or availability of food in the world. Typical of progressive midwest values, the annual prize is given without regard to race, religion, nationality, or political beliefs. Norm is personally committed to the Prize and every year spends more than a week in Des Moines for the award ceremony, the accompanying seminar and the associated Youth Institute.

The World Food Prize Youth Institute is one commitment to educating young people, but Norman also has been active directly in the classroom. In 1984, he became Distinguished Professor of International Agriculture at Texas A&M University. He began to move from CIMMYT to College Station each fall to teach a regularly scheduled class. In between times he took up the lecture circuit, hammering away at the need for constant attention to the global population problem, the need to increase food production, and the short sightedness of misguided environmentalists who fail to see that fertilizer, pesticides and science stand between humanity and starvation, and actually preserve land for nature. Norm also served as Cornell University's Andrew Dixon White Distinguished Professor at Large. For several weeks each year from 1983 to 1985 he enlivened the Ithaca campus with his forthright views on agriculture, environment, and development.

He was settling into the role of senior statesman to the world food community. The crisis spots of the 60's were enjoying an abundance of food the pundits had never imagined. Indonesia, Pakistan, India, China and Bangladesh, were all producing food in abundance. They no longer could be held hostage to other countries more fortunately endowed. Africa But a new element had entered the world food scene.

Africa.

In the 1960s Africa was exporting food to the rest of the world and was seen as a potential granary by the former colonial powers. The leaders of the newly independent African nations believed they had no reason to fear problems on the food front. After all, Africa was a place of abundance.

But those leaders failed to understand the impact rapid population growth could have. Just as Latin America and later Asia had experienced a ballooning of population, by the 1970s population growth rates in Africa had reached explosive levels. By the 1980s country after country was experiencing episodes of shortages. Then came the much-publicized famines of Ethiopia and Sudan.

The story of how the billionaire Ryoichi Sasakawa contacted Norm one day to ask why there was no Green Revolution in sub-Saharan Africa is worth re-telling. Norman replied that he didn't know anything about sub-Saharan Africa and anyway, he was too old. The next day Sasakawa's response came back, "I'm 13 years older than you are Dr. Borlaug. The central Africa initiative should have been done much sooner. No excuses, lets get to work." This was a challenge Norm could not resist, and he agreed to help organize a conference to address the Africa food problem.

He got former President Jimmy Carter and other luminaries like Father Theodore Hesburg to the meeting. Of course, no food gets produced by holding a conference, and a few months later, Global 2000, Inc. was established by Carter, Sasakawa and Borlaug to fight hunger in Africa. Ghana was one of the first countries to adopt the Global 2000 approach. Sudan was another and there civil war cut the program short, but maize production prospered in Ghana under the Global 2000 program. Currently the program is active in Ethiopia, Burkina Faso, Guinea, Malawi, Mali, Mozambique, Nigeria, and Uganda.

According to Dr. Gebisa Ejeta, a Purdue University Professor born in Ethiopia, the changes in Ethiopian agriculture are extraordinary. In his view, "the significance of the agricultural change in Ethiopia is that it was made possible through a conventional approach of extending modern agronomic practices... The success of the Norman Borlaug approach proves that there are niches in African agriculture that can be effectively addressed through conventional science and traditional approaches, provided that a concerted effort is planned in the development and extension of an appropriate technology -- to be implemented under the right policy environment."

The Borlaug approach that Ejeta finds has been so effective amounts to the tried and true elements Norman stressed in Mexico, India, Pakistan and elsewhere: high-yielding, well-adapted varieties created by plant breeding, appropriate fertilizer, and stable, remunerative prices to farmers. In one country after another, Norman Borlaug has helped governments to see that these elements are the keys to increasing food production.

The Next Horizon

It is no news to this audience that a new race of wheat stem rust, Ug99, has emerged and is threatening to spread from East Africa into the Middle East, Turkey, India, Pakistan and beyond. Norm sounded the alarm on Ug99 years ago and the world is slowly organizing to evaluate available wheat lines for their resistance. In additional to conventional approaches, he is also backing a different strategy, one that might uncover a more permanent source of resistance. All but one of all the world's major cereal crops is susceptible to the rust diseases. Only rice is not, but the reason why rice is immune is not at all well understood. Norman has put his influence behind a new research effort that is directed at understanding that question with the ultimate goal of transferring that resistance into wheat.

Ever the student and ever the teacher, with passion, persistence and persuasion, a clear focus on worthy goals, and science directed at solving problems, Norm has stressed the need to tackle problems rather than pursue fame, disciplinary knowledge or pre-conceived solutions. He has lit a spark in the minds of many young scholars in different parts of the world, in the conviction that this spark will develop into a flame that will motivate the efforts of these young people to improve the standard of living and make life a little more tolerable for the less-fortunate. That is the culmination of the life and work of Norman Borlaug.

Learning from Anti-GMO Campaigns: Revising Scientific Communication to Promote Public Support of Bt Brinjal in India

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Does Public Support Matter?

Researchers and developers of the Bt brinjal may presently think public support of their transgenic varieties is a non-issue. After spending years in varietal development and field trials, the Bt brinjal is only awaiting final approval from the national Genetic Engineering Approval Committee (GEAC) for its expected commercial release in India later this year. Farmers already anticipating the projected yield and economic benefits of Bt brinjal varieties, as recommended by extension agents and local agricultural research universities, are eager to plant the transgenic varieties.

The dominant position of Bt brinjal proponents might be summed up as: "If the farmers grow it, people will buy it." After all, the many varieties of Bt brinjal developed were all carefully chosen for regional preferences and, except for the Bt trait, bred to be virtually indistinguishable to their isogenic counterparts. Many scientists like to point out, as Dr. C. Kameswara Rao does in a blog post, that: "So far, no allergenic reactions [or toxicity in humans, environmental hazards, etc] have been reported during extensive biosafety tests on GE crops in several countries or on consumption of foods from GE crops for more than a decade by over 350 million people in North America (Rao, 2/26/09). In other words: if America and Europe have suffered no ill effects from over ten years of testing and consuming transgenic crops, they must be safe.

India's Hesitation Over Bt brinjal

India, however, may be reluctant to accept such reasoning on several grounds. Brinjal, as the second most highly-consumed vegetable in the country, is on everyone's mind and plate. Bt brinjal varieties will be the first edible transgenic crop in vegetables to be grown there and, for better or worse will be invariably linked with Bt cotton, India's only other transgenic crop, which already has a tainted reputation due to alleged and highly disputed links with livestock deaths, crop failures, and even farmer debt and suicides (Shiva, 2001; Shiva and Jafri Afsar, 2000). Furthermore, the Indian subcontinent is considered to be within the center of origin for brinjal (Paroda and Aurora, eds., 1991) so Bt brinjal advocates must be especially sensitive to these environmental and social issues when promoting their transgenic varieties. Much is riding on the public approval and performance of Bt brinjal in India, as this will set the stage for its international acceptance in Bangladesh, the Philippines, and any other countries where Bt brinjal varieties may be released.

Lessons From the Anti-GMO Opposition

Anti-GMO, anti-Bt brinjal factions, particularly organizations such as Greenpeace and the Coalition for a GM-Free India, are experts at using broadcast media and public demonstrations to target the natural skepticism of a largely science-illiterate population and turn public opinion against transgenics. Their strength lies not so much in the veracity of claims, as in their clear, compelling, and unified message which they are able to convey to a wide sector of the public, from policy makers to everyday consumers and farmers. This simple message -- that Bt brinjal should be banned from being grown and consumed -- gains further strength through the multitude of avenues they can use to appeal to their equally diverse audience. Environmental damage, the loss of biodiversity, human and animal toxicity, the capitalist and colonialist exploitation of farmers, and institutional and corporate corruption are just some of the negative aspects which these opposition groups have linked to transgenic crops. There are equally strong counter-arguments and benefits to transgenic crops to oppose these allegations, but pro-transgenic advocates have not integrated these into a cohesive response or publicized these as crop assets.

In addition to having a strong argument, these groups are able to transmit their message directly to the public through attention-grabbing pamphlets, stickers, signs, websites, even podcasts. Much of this headlining visual appeal also comes from their crafty demonstrations, protests, and reenactments which fuel public resentment and media interest, as people are encouraged to interact and even participate in these events, which many farmer groups, and civil societies have done (IBN-CNN, 3/17/08; The Hindu, 6/30/06; Businessworld, 1/30/09; IBN-CNN. 1/30/08). The strengths of anti-GMO groups—a strong, unified message and the effective use of broadcast media and appropriate modes of communication—can and must also become the strengths of Bt-brinjal advocates in order to earn public support for the cultivation and marketing of the crop.

Reframing the Bt brinjal: Instilling Trust in Technology and its Benefits

The creative, high-profile methods used by anti-Bt brinjal groups are also attractive to broadcast media outlets, resulting in the vast majority of the Bt brinjal news being heavily slanted against the crop (IBN-CNN, 3/17/08; The Hindu, 6/30/06; Businessworld, 1/30/09; IBN-CNN, 1/30/08). Even the headlines proclaim scandal and conflict within the scientific community. "Scientists oppose Bt brinjal cultivation," reads an article in The Pioneer (1/14/09), while an article in the Orissa Current News is titled: "Mahyco's Bt brinjal unsafe for human consumption: French Scientist" (1/13/09). If scientists can't agree on the safety of Bt brinjal, why should the public trust the technology? The researchers and institutions who have worked together to develop the Bt brinjal must now stand by their work and develop an equally strong message to counter the risks and commend the benefits of their crop. Rebuttals and follow-up studies which refute some of the "bad science" claims of the opposition cannot just be published in academic journals --they should also be explained in clear, confident manner and broadcast to advance public understanding and trust.

Get the Word Out: Effective Use of the Media

The media format and method of communication can selectively impact or exclude broad swathes of the population by being more or less suited to an audience of a specific social class, ethnicity, gender, or educational level. Information must be in a language understood by the audience- a particular problem in India where regional languages and dialects may vary even between different communities within the same village, yet most scientific research institutions still publish their informational materials in English. This alone can severely inhibit material transmission and understanding by rural communities whom these organizations may specifically be trying to reach (ISAAA, 2008).

Information broadcast by electronic means, through television, radio, the internet, and mobile phones, or disseminated as a tape or CD may not easily reach rural farmers or villagers who may have intermittent to no electricity or satellite access or are unable to afford or maintain the necessary equipment to receive news in this manner. Farmer dramatizations filmed in Tamil or animations in English to convey the benefits of Bt brinjal may be great for villagers in Tamil Nadu or the educated public in a major Indian city, but may be completely inappropriate for other audiences, for example, Telegu-speaking farmers in Andhra Pradesh (ABSP II, 2007). While computers and mobile phones are slowly making their way into the hands of rural villagers, live demonstrations and posted signs and placards in regional languages may still be the most effective means of communication.

Use Visual Aids A Picture is Worth a Thousand Words

Visual illustration in the form of photos, graphs, cartoons, short film clips, and even live plays or puppet shows can be more effective and influential in conveying a message and underlying tone than a written piece. The two pictures below (Figure 1a and 1b) are excellent examples for both the pro and con sides of the Bt brinjal debate. They serve to catch a person's attention and leave an instantly comprehensible and lasting impression of the message one is trying to convey.

Figure 1a. Photo of a Greenpeace demonstration against Bt brinjal (Frontline, 2006).

1b. Photo comparison of the yield from a transgenic Bt brinjal variety (lft.) versus a conventional variety (rt.) (Mahyco, 2006).

A good picture can be invaluable for its power to transmit a key concept, especially when an audience member has no time or is unable to read an accompanying message. Still, pictures need to be publicized to have an impact—the photo of the Greenpeace demonstration was part of a cover story on Bt brinjal in Frontline, a nationally circulated Indian magazine, whereas the photo of the differing brinjal yields was only to be found online in a Mahyco presentation made to the GEAC (Frontline, 2006: Mahyco, 2006).

The Picture of Success: A Market Winner

For all its claims of health and safety, yield recovery, protection from its major pest, and reductions in pesticide use, Bt brinjal, like any other commercial product, is up against a competitive and biased market. The responsibility of an agricultural scientist to his or her crop and research cannot just end with field testing and varietal release. The hearts, minds, and pocketbooks of millions of Indian farmers and consumers still need to be won over, and a well-organized force of opponents has been actively campaigning to prevent Bt brinjal from ever reaching farmers' fields. Don't the developers of the Bt brinjal owe it to themselves to ensure their research receives its due credit and their varieties a fair chance at being cultivated and valued around the world?

If so, they must appreciate the value of public support for their crops and earn that support by understanding and addressing the public's concerns about the technology. Researchers need to highlight and explain the positive social, economic, environmental, and health benefits of the Bt trait to consumers, and either acknowledge or rebut any inherent risks in candid, appropriately-framed broadcast public communication. Those scientists and developers who are comfortable openly representing their transgenic varieties must present a strong and unified message to gain widespread consumer acceptance of their crop. By engaging and involving the public and responding to their concerns in a savvy yet sensitive manner, pro-transgenic researchers and institutions can yet ensure that the Bt brinjal really will take root and flourish in India.

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Gene Technology for Crop Improvement with Special Reference to Development of Insect Resistant Chickpeas

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Gene technology (also called Genetic Engineering or Genetic Modification (GM)) is a significant contributor to modern agriculture and is expected to play an increasing role in crop, pasture and forest improvement.. Gene technology will enhance environmentally sustainable developments in agriculture. Food from genetically modified (GM) plants will contribute to food security. In the current scenario of food availability, there is an urgent need to promote gene technology research in order to increase food security.

Food and Nutritional Security can be Achieved through Improvement in Agriculture:

Improvements in agriculture result in food and nutritional security. There are several complicated reasons for food scarcity. These include increased population, increased wealth, decrease in area of productive agricultural land, loss of agricultural diversity, emergence of new plant diseases, climate change due to global warming that leads to several abiotic and biotic stresses, urbanization and industrialization, etc. Maximum emphasis should be given in production of pulses, coarse cereals and vegetables wherein conventional breeding technology seems to fail to increase their production as per the requirement by 2020. Pulses, coarse cereals and vegetables were not considered as main crops of interest in early generations of agriculture and their productions need to be increased at much faster pace for meeting the requirement by 2020. Biotechnology, especially gene technology will definitely provide an alternative source for increase in production. The most opponent of GM, the European Union has also acknowledged that GM crops can play an important role in mitigating the effects of the food crisis. World wide about 125 million hectares area has been covered under the GM crops in different countries. The US being the leader amongst all by cultivating 53 % GMOs out of their total crop areas. The US is being followed by Argentina (17%), Brazil (11%) and Canada (6%). Majority of these crops are herbicide and insect resistant soybean, corn, cotton, canola and alfalfa.

Genetically Modified Produces:

These include food, feed and fibre. There are two categories of GMOs. 1) Products containing genetically modified DNA and 2) Products that are genetically modified but do not contain genetically modified DNA. Some of the important genetically modified foods are, Flavr Savr tomato, insect resistant corn, herbicide resistant soybean, nutritionally improved rice (Golden rice) etc.

Genetically Modified Plants being Field Tested in India:

Among the several food crops that are being genetically modified and field tested all over the world, the important ones include, Sweet potato resistant to virus, Rice with increased iron and vitamins, a variety of plants that are able to survive extreme weather conditions. In India, currently several GM food crops are being field tested. Examples of GM food crops under field trials along with gene of interest and institutes / industries undertaking such trials are presented in Table 1.

Table 1: GM Crops Allowed for Large Scale Field Trials in India

No	*Crop*	*Institute/Industry*	*Event/s*
1	Brinjal	Mahyco, Mumbai	Cry1Ac
		Sungro Seeds, New Delhi	Cry1Ac
		IARI	Cry1F
2	Cabbage	Sungro Seeds, New Delhi	Cry1Ac
3	Cauliflower	Sungro Seeds, New Delhi	Cry1Ac
4	Corn	Mahyco, Mumbai	Cry1Ab
		Metahelix Life Science, Bglr	Cry1Ab
5	Groundnut	ICRISAT	Coat Protein of IPCV
6	Okra	Mahyco, Mumbai	Cry1Ac
7	Rice	Mahyco, Mumbai	Cry1Ac
8	Tomato	IARI	Antisense replicase gene of leaf curl Virus
		Mahyco, Mumbai	Cry1Ac

In the following sections we have discussed about our experiences in genetic modification of an important pulse crop that is chickpeas to confer resistance against insect pests.

Gene Technology for the Improvement of Chickpeas to Confer Resistance Against Weevils and Pod Borers:

Chickpea (*Cicer arietinum*) is the most important pulse crop of India and is one of the major sources of protein for the vegetarian population. Two very serious insect pests of chickpeas are weevils (*Callosobruchus sp*) and pod borers (*Helicoverpa armigera*). There is little or no natural resistance to these insects in the cultivated varieties, which hinders the development of resistant chickpeas using conventional breeding methods. With the development of gene technology it is now possible to incorporate insect resistance genes from unrelated sources into this important grain legume.

We are working on the introduction of insect resistance gene(s) into chickpea using gene technology. Firstly, with the funding from the McKnight Foundation, USA, we have transformed chickpeas using a bean α-amylase inhibitor (α-*ai*) gene to confer resistance against the stored grain pests in the *Callosobruchus* group (Sarmah *et al.*, 2004 Mol Breeding 14, 73-82). Transgenic lines were found to protect the seeds from attack of the pest when compared to control seeds (Figure 1). It is now possible to begin the process of gaining approval to incorporate these lines into an introgression breeding programme in order to transfer the gene into other important desi and kabuli type chickpea cultivars for various regions of India.

Figure 1: Seeds of α-ai transgenic chickpeas (bottom row) were tolerant to stored grain pest

A public concern:

Transgenic plants have been developed keeping in view:

2. Site specific recombination using Cre-Lox system
3. Co-transformation using a twin binary vector
4. Use of transposable elements

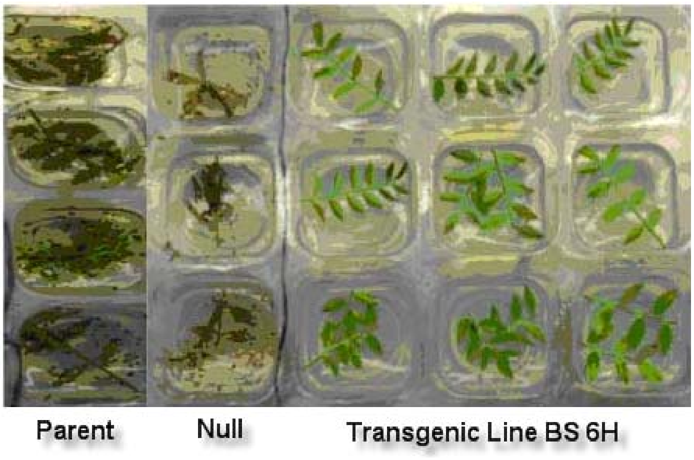
In our all recent attempts to transform chickpeas using important genes of interest we took made our gene constructs in such a way that the selection marker gene can be eliminated in the segregating progeny of transgenic lines.

In our collaboration we have also transformed chickpeas using two different Bt genes (*Cry1Ac* and *Cry2Aa*) to confer resistance against pod borers (*Helicoverpa armigera*). Considerable effort was devoted to obtaining chickpeas with different versions of the Bt proteins that have already been approved for release in several countries.

For reconstruction of Bt genes we used a twin binary vector which will facilitate the removal of selection marker gene from the segregating progeny. However, from our current experiences we have noticed that in most of our transgenic lines both transgenes cosegregated. The safety of *nptII* has been well established in the past and transgenic lines containing it have been approved by the European Food Safety Authority (EFSA).

With the help of DBT, New Delhi and two international collaborative programs; an Indo-Swiss Collaboration in Biotechnology (ISCB) and an Australia India Strategic Research Fund (AISRF), we have successfully reconstructed Bt genes (*Cry1Ac* and *Cry2Aa*) in Agrobacterium-based binary vector systems for gene transfer.

We transformed chickpea with a chimeric Cry2Aa gene and positive lines were established in soil in the greenhouse. Molecular analyses of the progeny suggested that segregation of the transgene was consistent with a Mendelian 3:1 ratio. Insect bioassays using the progeny of selected lines showed differential resistance to pod borer (*Helicoverpa armigera*) larvae, depending upon the level of expression of the Bt protein. A high expressing line was found to confer near complete protection against the pod borer (Figure 2). We have also noted that some of our lines showed reduced plant vigour. Further research is needed to determine whether this can be overcome by backcrossing to advanced breeding lines. Currently, we have transferred two of our high expressing lines and one medium expressing line to a private seed company, Mahyco, in India for further evaluation and product development.



Acknowledged: Indo-Swiss Collaboration in Biotechnology program

Figure 2: Insect bioassays using a high expressing Bt-Cry2Aa chickpea line (BS 6H) confirmed resistance of transgenic line against pod borers

Currently we are transferring a *Cry1Ac* gene to the chickpeas. Several transgenic lines have already been generated. We are selecting an agronomically acceptable Cry1Ac line. In the longer term we propose to cross the best Cry 1Ac line with the best Cry 2Aa line in order to pyramid both these genes in a single plant.

Conclusion

India has not yet allowed commercial release of any GM food pulses although it is very supportive of transgenic plant research. In order to alleviate poverty and to feed the growing population, Indian agriculture will need to adopt GM technology to help meet food and nutritional requirements. Pulses are the most common food in India's everyday meal for the vegetarian population. Chickpeas are the most popular pulse but insect pest infestations lead to heavy losses in the cultivation and storage of this valuable crop. GM technology is the most appropriate approach to the development of insect resistant chickpea varieties. We have collaborated for several years in order to solve the insect problem. We gratefully acknowledge the Indian Government's Dept. of Biotechnology, the Ministry of Science and Technology as well as the International agencies, the McKnight Foundation, USA, the Indo-Swiss Collaboration in Biotechnology, the Australia-India Strategic Research Fund for supporting our research for several years. We are confident that with continued funding we can deliver insect resistant chickpeas to the farmers of India.

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