Utilizing The Potential of Genetic Engineering: Lessons Learned from Bt Cotton in India

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Roadmap of Thesis

Legally released into India in 2002, Bt cotton is genetically modified through the insertion of one or more genes from a common soil bacterium, Bacillus thuringiensis in order to control for the pink bollworm pest (Stewart, 2007). I hope to compile lessons learned from the development and use of Bt cotton (known commercially as Bollgard) in order to present the ways that other biotechnology crops can improve food security and provide positive ecological benefits in India. In order to answer these questions, I will historicize cotton's role in India as a way of understanding its presence today. Then, I will examine Bt cotton's effect on local ecology and farmer incomes in India in order to gain an understanding of what the short and long term effects of using Bt cotton may be. I will then propose new ways that local communities can be systematically included in research and public policy surrounding development of other biotechnology crops in India. I conclude by proposing the main considerations that should effect how research, policy, and public advocacy are approached in biotechnology to best serve farmers in India.

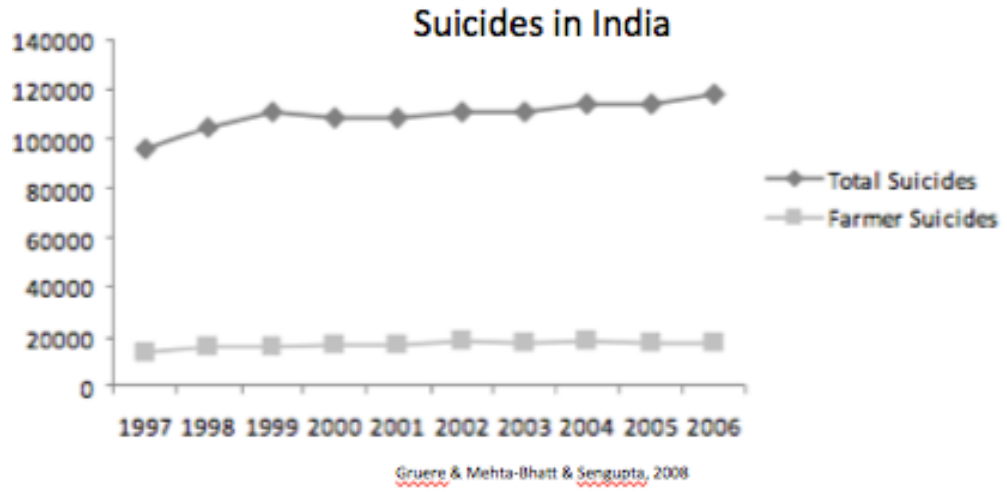
Flawed Research and Detrimental Discourse

As I began doing research for this paper I based many of my ideas on a paper titled "Deconstructing Indian Cotton: Weather, Yields, and Suicides". While the paper provided a more nuanced approach for understanding the suicide epidemic among Indian farmers[1], it had been published in the journal *Environmental Sciences Europe* which is infamous because it is the journal that published the highly controversial Seralini study

[1]Farmer suicides in India have hovered around 15,000 since 1997 (Gruere & Mehta-Bhatt & Sengupta, 2008).

[2] Contributory experts have knowledge and experience in a specific field that allows them to make claims that others find credible. Interactional expertise describes someone

which used highly disputed methods to claim a link between genetically modified maize and the development of tumors and other severe diseases in rats. *Environmental Sciences Europe* published the retracted paper despite the questionable methods in an attempt to continue discussions about the study's findings. Nevertheless, in publishing a study with an invalid methodology, the journal facilitated public discourse that took a more severe stance towards genetically engineered crops.



However, to condemn all studies in *Environmental Sciences Europe* as inherently flawed because the journal chose to publish the Seralani study takes away from other potentially beneficial research published by this journal. "Deconstructing Indian Cotton: Weather, Yields, and Suicides" provides a starting point for understanding the highly nuanced farmer suicide epidemic in India. It draws on weather patterns, insect ecology, market forces, and cultural factors which all are potentially influencing the rate of farmer suicide. This thesis does not use any of the data put forth from *Environmental Sciences Europe,* however I do use "Deconstructing Indian Cotton: Weather, Yields, and Suicides"

as a starting point for problematizing the farmer suicide narrative in India as well as understanding the myriad factors that affect farmer livelihood in rural India. In doing so I hope to create a conversation that examines the considerations that should be taken for improving farmer livelihood in rural India as well as what role biotechnology can play in this process.

Colonial Roots of Cotton in India

A seminal book released in 2014 titled "Empire of Cotton: A Global History" traces the role of cotton as a catalyzing force of the Industrial Revolution. Additionally, it puts forth a way of understanding modern capitalism through two lenses: War Capitalism and Industrial Capitalism, both of which played an instrumental role in the rise of cotton as a global commodity crop. War capitalism relied on violence, particularly the removal of people from Africa into forced labor in the American South, in order to initiate cotton production in that region; Industrial Capitalism describes how a seemingly "hands-off" state was actually highly interventionist and also necessary to create infrastructure and provide capital for large-scale cotton projects in the American South and India.

Both War Capitalism and Industrial Capitalism played a pivotal role in the rise of cotton cultivation in India. After the dramatic reduction in the supply of cotton, brought on by the Civil War and the end of slave labor in the United States, the Manchester Chamber of Commerce and Manchester Cotton Supply Association were in a panic to secure high levels of raw cotton at low cost to keep their manufacturing industry afloat. With the decline of the cotton supply, these groups pressured the British colonial government to secure significant cotton exports from places outside of the American South (Beckert, 2014). The

British reconciled these demands by intensifying the extraction of cotton from India using the East India Trade Company.

British colonial officials also "distributed American cottonseeds to Indian peasants, worked on changing Indian cotton strains, and encouraged them to use new agricultural methods" in an attempt to increase cotton production to supply the British textile industry. Nevertheless, "local peasants often resisted such projects, for not only was the planting of new cotton strains more labor-intensive, but it was also riskier because they had not been proven in the local climate" (Beckert, 2014).

The desire of British cotton manufacturers to increase cotton supply by increasing production in India had devastating consequences for millions of laborers in India. In an attempt to improve efficiency of cotton production, farmers were consolidated into fewer farms that were larger than before British development initiatives. This process displaced many rural smallholder farmers who became dependent on larger farms for employment and wages to purchase food and other basic needs. Additionally, the consolidation of small farms into large cotton farms decreased the diversity of crops grown and led to increased dependence on cotton prices for income. In the province of Berar in central India, farmers became so dependent on cotton prices for the ability to purchase other basic goods that in the late 1870s six to ten million Indians died from starvation because cotton prices fell as food grain prices rose putting food out of reach for many cotton producers (in fact, food grains continued to be exported from Berar to Britain) (Beckert, 2014). British colonial efforts focused exclusively on increasing cotton yields of the Indian farmer. Success or failure was measured by whether or not yields increased to a

level of supply that met British manufacturers satisfaction which had devastating consequences for millions of Indian laborers.

From Matters of Fact to Matters of Concern: Deploying Critique

Bruno Latour's "From Matters of Fact to Matters of Concern" offers a framework for engaging with "facts" which are useful when evaluating research about the effects of Bt cotton in India today. Most studies about Bt cotton rely on researcher's own data or analyze data collected by the Government of India or the International Services for the Acquisition of Agri-Biotech Applications. Conclusions drawn are empirically based and therefore become heavily critiqued; researchers often have qualms or concerns about how data was gathered and how this leads to biases when making conclusions. Comprehensive literature reviews do cite many biases in studies about Bt cotton in India. Nevertheless, to dismiss all empirical studies on Bt cotton because of biases is to "weaken rather than strengthen their claim to reality" (Latour, 2004). Scientists and academics working in the field of Bt cotton should invite critics of their research to "come ever closer to the matters of concern we cherish," and tell critics: "Yes, please, touch them, explain them, deploy them." (Latour, 2004). The research that I examined to discuss the effect of Bt cotton on farmer income and ecological effects in India address two of the main biases in existing literature: selection and cultivation biases. By recognizing biases in existing research, we can begin to discuss what lessons can be learned from the proliferation of Bt cotton and applied to future research in biotechnology.

Selection Bias

Selection bias occurs in studies when researchers study the yield effects of Bt cotton in the early years of adoption. Typically early adopters of technology are already in a more advantaged position than later adopters of technology because they have more knowledge or capital which allows them to know about new technologies or have the ability to invest in new technologies as well as endure any risk or perturbation associated with technology adoption (Rogers, 2003). Therefore measuring the yields of only the farmers who adopt Bt cotton creates a selection bias—we would expect these adopters to already have higher initial yields than farmers who do not adopt because of their initial advantaged position.

Cultivation Bias

Cultivation bias "results from seeds that are relatively costly, or for which the farmer has particularly high expectations, being planted in preferred locations and given greater care and expense than other seeds. This has major impacts on yields." (Stone, 2012, pg. 66). The amount of care and resources given to high cost seeds has been widely recognized (Kathage and Qaim, 2012; Narayanamoorthy and Kalamkar, 2006). It is important to note that the increased level of care attributed to Bt seeds, especially in the early years when they were far more expensive than conventional seed, may have influenced the higher yields associated with growing Bt cotton seeds.

India as a Case Study

Today, India is second in the world in cotton exports. In 2015/2016, cotton production is estimated at 29.3 million bales (480 lb. bales) from 12 million cultivated hectares (45,560 square miles), compared to 10.6 million bales from 7.6 million cultivated hectares (29,602 square miles) in 2002 when Bt cotton was officially released (Singh, 2015; Sood, 2015). The predicted average yield of cotton (assuming a normal monsoon season) is 531 kg per hectare which is still well below the global average of 800 kg per hectare (Sood, 2015). Furthermore, cotton is primarily grown by smallholder farmers with farm sizes less than 6 hectares (.02 square miles) who allocate 1.5 hectares (.006 square miles) on average to cotton production (Kathage and Qaim, 2012).

Many contemporary studies as well as new projects surrounding biotechnology focus on improving yield. Measuring the success or failure of Bt cotton strictly through its effect on yield offers a myopic understanding of Bt cotton's effects as well as potential benefits that biotechnology can offer farmers. Additionally, as I have shown, focusing only on improving yields has in the past created food insecurity especially in resource poor areas in rural India. While the first decade of research was primarily focused on Bt cotton's effect on yield, it is imperative that the next decade of research on Bt cotton addresses impacts on poverty and inequality in farming communities, effects on human health and the environment, implications for farmer knowledge systems and extension, and implications for female farmers, as compared with male farmers (IFPRI, 2009). This thesis aims to examine how biotechnology is a potential tool, among many, to provide food security in rural India as well as considerations for how research, policy, and public advocacy should be approached in biotechnology in India.

Effects on Yield and Income

Bt cotton is designed using a soil bacteria (Bacillus thuringiensis) within the cotton plant that kills or deters the pink bollworm. In theory, this allows farmers to spray fewer pesticides leading to lower costs and increased income. By 2008 nearly all cotton farmers were using cotton seeds with the Bt trait and today Bt cotton continues to be used by nearly all cotton farmers. Overall, Bt cotton outperformed conventional cotton in periods between 2002 and 2004 as well as between 2006 and 2008 due to lower crop losses from better pest control. This led to higher yields equivalent to a 24% increase over mean yields on conventional plots as well as profit increases of 50%. Household consumption expenditures by adopters of Bt cotton also were estimated to increase by 18% compared with non-adopters between 2006 and 2008 (Kathage and Qaim, 2012). Another study found that from 2003 to 2007 cotton yields rose 18% across four villages in Warangal District (Stone, 2011). A third study found that since its introduction in 2002, Bt cotton has increased total yield by .3 and .4 percent per percentage adoption. The study also found the use of fertilizer and the increased adoption of hybrid seeds to have contributed significantly to increases in yield over time (Gruere and Sun, 2012).

Effects on Insect Ecology

Nevertheless, pests have become resistant to Bt crops and secondary pest outbreaks are recurring problems for some Bt cotton farmers across India making it unclear if the increases in income due to fewer pesticide purchases will continue in the long run. The rise of attacks by "sucking pests" such as whitefly, cotton aphid, mealybug, and mirid and the use of insecticide needed to treat these secondary pests are well documented (Stone, 2011). In October 2015, cotton farmers in the Punjab region lost nearly 60% of their cotton

crop to the whitefly pest. In response, the Cotton Corporation of India was asked by the Union Textiles ministry to immediately provide minimum price supports for farmers in the region (Times of India, 2015).

Whitefly pests have been a growing concern since the release of the Monsanto-Mayhco created Bollgard cotton seed in 2002. There is a concern of a rising threat from non-target pests, which may make farmers respond by increasing purchases of pesticides aimed at sucking pests, possibly increasing costs and thus decreasing farmer profits. Additionally, Monsanto has released stronger Bt cotton strains with a double stacked generation of Bt that "provides farmers with the same benefits as the original Bollgard product, as well as against other cotton pests" (Monsanto, 2015) as well as a double stacked seed that also includes Roundup Ready technology. It is unclear if these new products will deter non-target pests, or if farmers are now increasingly dependent on private seed companies for the release of the next "improved" Bt seed. Additionally, putting Roundup Ready technology into Bt cotton may cause weeds to become resistant to glyphosate, the main ingredient in Roundup (Neuman and Pollack, 2010).

The increasing reliance of farmers on "new and improved" seeds are contributing to farmers being less capable of making decisions based on the changing insect ecology which could make them vulnerable to future changes in insect ecology (Stone, 2011). Furthermore, the introduction of Roundup Ready cotton signifies farmers relying on technical solutions (which they play no role in developing or implementing) to solve agricultural problems.

Measuring Success

As I mentioned above, measuring only yield does not necessarily benefit the farmer. While Kathage and Qaim demonstrate the increases in farmers' expenditures and profits, they also mention that it is unclear if their results will hold true in the future given changing insect ecologies and the constant need for new seeds or pesticides. It is necessary to find ways to measure long-term success of Indian farmers by a metric that farmers themselves feel is suitable. Once this is done, it is possible to invoke new methods of knowledge production and policy making to better actualize the needs of rural farmers.

Democratizing Science and Policy

Engaging the expertise of different members of the public can help frame and execute research projects and create policy that addresses the issues that local communities face in a more complete way. Three groups of "experts"[2] can be roughly classified in order to systematically include various stakeholders in the creation of research initiatives and policy prescriptions that are more robust. It is less important to accurately classify which individuals fall into which category and more important to have the groups that are making important decisions be comprised of various types of experts, or people who know the world in a variety of different ways.

How can farmers, scientists, public advocacy groups, economists, and the Government of India renegotiate their means of creating knowledge to initiate scientific

[2] Contributory experts have knowledge and experience in a specific field that allows them to make claims that others find credible. Interactional expertise describes someone who has a deep understanding of the contributory experts field (like an art critic talking with an artist) and can therefore engage in critical dialogue with them. Referred experts have a deep understanding of their own specific field but can still use their understanding of what it is to possess expertise to engage critically with people from different fields (Castree, 2014).

endeavors, fund agriculture projects, and create new policy that more clearly listens to and reflects the needs of local groups? Genetic engineering research in India must systematically include various experts who know the world in different ways in order to create research agendas that are more fitting to local desires.

Methodology

In order to understand the primary issues that should be considered in how biotechnology research, policy, and public advocacy are approached to best serve farmers in India, my methodology involved several steps. First, I reviewed a plethora of scholarly articles as well as comprehensive reports written by the International Food Policy Research Institute which described in detail the various effects of Bt cotton on yield and farmer livelihood in India. When reading these studies I tried to determine whether or not the study indicated that Bt cotton was a driving factor of increased yields, what other factors influenced yields, and whether or not increased yield correlated to increased income.

Additionally, I spoke with many leading scholars in the field of Bt cotton in India as well as others who study agricultural science and agricultural economics with a focus on biotechnology development or effects of biotechnology proliferation. Furthermore, I received a grant from the Student Academic Affairs Board of Lewis and Clark College allowing me to travel to India during my spring break to conduct interviews with researchers in Delhi and Hyderabad, as well as an agricultural officer and farmers in Warangal District. The insights these people offered were instrumental in shaping the conclusions and recommendations that I draw in this paper.

Recommendations and Future Considerations

Research

Research institutions need to develop programs that make it easier for public researchers to commercialize new biotechnology products that they create. In my interview with Dr. Kiran Shama, Principal Scientist at the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), I learned about the Platform for Translational Research on Transgenic Crops, an entity that will develop physical infrastructure to "conduct transgenic research, evaluate specific concepts, ideas and technologies and transfer the evolved technology to the private or public sector for advancement" (Department of Biotechnology, 2009). The platform will allow public researchers access to many of the resources that allow the private sector to be so successful in the commercialization of biotechnology crops.

Additionally, future research endeavors ought to focus more on improving subsistence crops, not just commodity crops like cotton. In doing so, farmers will have the ability to diversify the crops they grow and potentially feed local communities not just supply raw goods to global supply chains. One example of this is taking place in Rajasthan where farmers are beginning to plant a short duration variety of pigeonpea which was developed by ICRISAT. Short duration pigeonpea requires fewer inputs and thrives well in limited water conditions; its short maturation season also allows farmers to grow post rainy season crops like wheat, chickpea, and mustard which can provide additional income to farmers (ICRISAT, 2016).

It is more likely that public sector research institutions such as ICRISAT will lead the development of subsistence crops in India because most subsistence crops have seeds that can be saved and reused for several seasons. Public institutions are not responsible for maintaining profits to shareholders and do not require the yearly revenue that private companies obtain from annual seed sales. For this potential revenue stream, genetically modified cotton has become a key focus of private companies because it requires annual purchase of new seeds[3]. When I interviewed farmers in Warangal District they told me that they were going to plant less cotton this year due to labor shortages especially among women laborers who are preferable because they work harder and can be paid paid lower wages than men. Additionally, farmers said that the minimum support prices at which the Government of India bought cotton was too low to make cotton cultivation feasible. Farmers said that they would be replacing cotton with chili because they received a higher market price, or maize, and pulses, which are subsistence crops.

Policy

One step that policy makers can take is to increase focus on biotechnology and other agriculture projects. In 2013 there were 263 million people working in agriculture, which is over half of all workers in India (Shrinivasan, 2013). Because such a high percentage of the Indian population lives in rural areas and practices agriculture, it is imperative to address their needs. Many political groups can appease these rural areas and remain popular if they address agricultural issues. Political support for rural communities is recognizable in India today through extension services and subsidies for farming

[3] Since 1995 (following the introduction of hybrid varieties) cotton seed has rarely been saved by Indian farmers.

technologies.

For example, when I was waiting to meet with the Mandal Agricultural Officer in Warangal District I watched government employees distribute tarps, at a 50% reduced rate thanks to government subsidies, to farmers to be used to cover spices. The Agricultural Officer also told me that the government subsidizes Bt cotton seeds as well as PVC pipes which are used for irrigating fields. Although these subsidies are not specific to biotechnology, they provide important capital to fund projects that can improve agricultural efforts in rural areas.

Another outreach program initiated by the Indian Government through the Ministry of Agriculture and Farmers Welfare is mKisan which provides a platform for farmers to receive information using the internet, touch screen kiosks, agri-clinics, private kiosks, mass media, service centers, call centers, and physical outreach services. One of the most highly touted programs of mKisan relies on farmers' use of cell phones. As of 2014, there were about 380 million mobile telephone connections in rural areas (Ministry of Agriculture and Farmers Welfare, 2014). Since the programs inauguration in July 2013, nearly 50 million messages have been sent to farmers throughout India (Ministry of Agriculture, 2014). The government can quickly reach farmers via SMS messaging[4] and provide information to them that is specific to their language, method of agriculture, crop grown, and location. In doing so, farmers receive information and potential solutions to problems they face on a very local scale.

Another way of broadly improving research initiatives and policies for agricultural

[4] Voice messages are also available for semi-literate and illiterate farmers.

projects is to systematically include farmers and other knowledgeable individuals in a community in the process of determining which projects or technologies to invest in. One's positionality (or place in the world as determined by race, gender presentation, and economic standing) acts as a constraint for how we interact with the world, therefore understanding ones own as well as others' positionality is essential for understanding agricultural issues in a more complete way. One attempt at incorporating a wider range of perspectives involves utilizing different forms of expertise as described earlier in this paper. In doing so, there is potential for improving agricultural research and policy.

For example, if the government wanted to initiate an agricultural project aimed at improving food security in Warangal District they could include the women who are responsible for cooking for their families, farmers who grow locally consumed subsistence crops, formally educated scientists in nutrition, and formally educated government employees involved in city planning and transportation services. By relying on the knowledge of local people as well as formally educated professionals the government could initiate research projects or food security initiatives that more accurately address the issues faced by local communities.

Public Advocacy

One of the leading organizations in India that is strongly against genetic engineering is Navdanya ("Nine Seeds"). This organization focuses heavily on the ability of farmers to share and save seeds and recognizes genetic engineering as a direct threat to farmers' ability to do so. While genetic engineering should not infringe upon farmers' ability to

share and save seeds, it should be noted that certain seeds, such as cotton seeds, have not been saved in India since the release of hybrid varieties in the 1990s, far before the release of Bt cotton[5]. Therefore it is untrue to claim that Bt cotton is infringing upon farmers rights to save seeds because farmers did not save cotton seeds nearly a decade before genetically engineered cotton arrived.

Navdanya also offers classes to farming communities in India in order to train farmers in organic agriculture to promote biodiversity and increase the amount of nutrition grown per acre. Valuing agriculture on the amount of nutrition grown per acre is very different than focusing on maximizing yield of crops per acre. While most genetically modified crops aim to impose yield-improving traits into existing crops, some genetic modification aims to fortify crops with higher levels of nutrition. For example, there is potential to create a vitamin A fortified groundnut that could provide nutritional benefits to Indian farmers[6]. Would Navdanya oppose this nutrition enhancing crop simply on the grounds of it being genetically modified? Public advocacy groups like Navdanya must recognize the potential of biotechnology as a new useful tool if it is developed and commercialized with the public's interest in mind. Rather than disavowing all biotechnology, it is important to recognize the benefits that some biotech crops can provide, especially if developed and implemented by public institutions for subsistence agriculture.

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[5] Hybrid varieties lose vigor after the first seasons of planting and must be repurchased annually.

[6] Dr. Kiran Sharma mentioned this in an interview and was excited by the widespread consumption of groundnuts in India as well as the high oil content of groundnuts which allows for inserted vitamins to remain stable over time.

Taking "Nature" Out of It

Anti-GMO groups, especially in the West, aim to discredit the usefulness of genetic engineering by pejoratively claiming that GMOs are "unnatural". Many Western cultures have an Environment/Society binary (among others), which forces different phenomena into neat categories that, in reality, exist on a continuous spectrum. Domesticating plants, whether through genetic engineering or selecting plants with desirable traits over generations, involve human intervention into non-human realms. If this destabilizes "naturalness" and creates perceived risk and stigmatization then it ought to be recognized that all domesticated crops, not just GMOs, are risky and "unnatural". Instead of evaluating the merits of biotechnology based on whether or not a genetically engineered crop is "natural", we ought to emphasize who is developing new products and what their intended uses are. In doing so, perhaps we can understand the usefulness of a product based on who is developing it and how it is being implemented rather than argue about whether or not it is "natural".

Furthermore, an agricultural field is a hybrid place comprised of many factors that exert force on a variety of scales. Appreciating how these factors and scales interact can allow us to deconstruct "nature" as a fixed entity that is inherently separate from humans and rather understand the ways that humans interact with and are affected by the non-human world. Practicing agriculture allows humans the opportunity to correspond with myriad ecological factors (climate, pests, soil conditions), economic factors (markets, costs, revenue), and human factors (character, labor, community). In doing so, we are neither in nature nor out of nature, but rather working in a *place* that is being influenced by many

forces. Understanding the forces that come together to make a place can allow us to know the world in a more critical and engaged way.

Future Research

I attempt to put ideas on how biotechnology can offer potential solutions to problems that rural Indians face. I did not closely examine the forces driving farmer suicides. Some argue, incorrectly, that Bt cotton has caused the suicide epidemic of Indian farmers despite the constant level of farmer suicides which pre-dates the introduction of Bt cotton in 2002 by nearly a decade. A more apt correlation exists between farmers' debts and suicide and future research should examine programs which can lower input costs for farmers, increase market prices for the crops they sell, and provide a safety net for farmers when crops fail and they can't pay back loans. Farmers are increasingly at the whim of monsoon rains and when crops fail they must try to secure loans from private money lenders who charge exorbitant interest rates. Understanding how to mitigate inadequate rainfall as well as provide capital to indebted farmers could perhaps help reduce the tragic suicide epidemic in India.

Another area of study that warrants future research is the effect of new technology on historically marginalized groups. In India it is typical for men to apply pesticides on cotton crops while women are responsible for picking cotton. Bt cotton requires less pesticide spraying, and therefore less labor for men, and has the potential to increase the number of harvests and therefore increase labor and income for women. Nevertheless, the farmers that I spoke with mentioned that they would plant less cotton this year because government support prices were too low and there was not enough available labor. Does

this mean that women are finished doing the hard labor of picking cotton at wages lower than their male counterparts and using their labor to do other tasks? Understanding the social dynamics and economic impact of women's labor in rural India is instrumental for initiating research and agricultural development that is more inclusive and more fully addresses rural issues.

Future research should also examine how intervention in the cotton supply chain can occur in order to encourage ecologically beneficial production practices as well as a fair price for cotton farmers. Creating rigourous standards for organic and fair-trade products can provide farmers and local cash crop producing communites with ecological benefits as well as increased revenue for crops they produce. In doing so, perhaps farmers can find a solution to increasing debts as well as find new solutions for mitigating pests and fluctuating rainfall.

Utilizing the Potential of Genetic Engineering

Genetic engineering is one potential tool, among many, that if properly utilized can have significant benefits for farmers. Genetically engineered crops are developed and utilized in many different ways, each of which contributes to different outcomes for various stakeholders. Bt cotton in India was developed privately and used in commodity crop production. This varies greatly from genetic engineering projects that are developed by public institutions, such as ICRISAT, and used to produce subsistence crops for local consumption. Furthermore, systematically including local communities in research and policy development can lead to solutions that better address local conditions.

While the effects and implications of genetic engineering are often overshadowed by the voluminous amount of confusing and complex information involved in GMO debates, it is imperative to refocus the genetic engineering debate around who is developing new biotechnology crops and how they will be used. This shift must be made to create a straightforward landscape for researchers and scientists in the field, to define a clear path for policy makers to follow, and to establish a less polarized discourse among public advocacy groups, private institutions, and government entities.

Bibliography

Beckert, Sven. 2014. *Empire of Cotton: a Global History*. New York: Random House LLC.

Castree, Noel. 2014. *Making Sense of Nature.* New York: Routledge.

Department of Biotechnology. 2009. "Platform for Translational Research on Transgenic Crops". *Biotech News.* Volume IV, No. 2.

Gruère, Guillaume P., Purvi Mehta-Bhatt, and Debdatta Sengupta. 2008. *Bt Cotton and Farmer Suicides in India: Reviewing the Evidence*. Intl Food Policy Res Inst. http://books.google.com/books?hl=en&lr=&id=v43rAqABmKsC&oi=fnd&pg=PR6&dq=%22Weighted+average+of+the+effects+of+Bt+cotton+relative+to+non-Bt+cotton+by+state,+using%22+%22Farmer+and+total+suicides+in+India,%22+%22Summary+of+published+studies+on+the+economic+effects+of+Bt+cotton+at+the+farm+level+in+India%22+&ots=z07UEvfdij&sig=exYFEnOJJAXBoxjcot8-0hU9VXE.

Gruere, Guillaume P., Yan Sun, and others. 2012. "Measuring the Contribution of Bt Cotton Adoption to India's Cotton Yields Leap." *International Food Policy Research Institute (IFPRI) Discussion Paper* 1170. http://mmbindia.com/pdf/IFPRI%202012%20-%20Measuring%20the%20Contribution%20of%20Bt%20Cotton%20Adoption%20to%20Indias%20Cotton%20Yields%20Leap.pdf.

Heldke, Lisa. 2015. "Pragmatist Philosophical Reflections on GMOs." *Journal of Agricultural and Environmental Ethics* 28 (5): 817–36. doi:10.1007/s10806-015-9569-4.

ICRISAT. 2016. "Short Duration Pigeoppea a Boon to Farmers of Rajasthan, India". http://www.icrisat.org/short-duration-pigeonpea-a-boon-to-farmers-of-rajasthan-india/.

Jayaraman, K.S. 2001. "Indian Seed Bill Forges New Ground." *Nature Biotechnology* 19 (10): 895-896.

Kathage, J., and M. Qaim. 2012. "Economic Impacts and Impact Dynamics of Bt (Bacillus Thuringiensis) Cotton in India." *Proceedings of the National Academy of Sciences* 109 (29): 11652–56. doi:10.1073/pnas.1203647109.

Latour, Bruno. 2004. "Why Has Critique Run Out of Steam? From Matters of Fact to Matters of Concern." *Critical Inquiry* 30 (2): 225–48.

Ministry of Agriculture and Farmers Welfare. 2014. "mKisan Portal- Mobile Based Services for Farmers". *Government of India*. http://mkisan.gov.in/images/Detailed%20Writeup%20on%20mKisan.pdf.

Monsanto. "Bollgard Cotton Timeline". *History of Bollgard Cotton.* Date Accessed: March 15, 2016. http://www.monsanto.com/improvingagriculture/pages/history-of-bollgard-cotton.aspx

Neuman, William, Andrew Pollack. 2010. "Farmers Cope with Roundup-Resistant Weeds". *NY Times.* http://www.nytimes.com/2010/05/04/business/energy-environment/04weed.html?pagewanted=all&_r=0

Rivoli, Pietra. 2015. *The Travels of a T-Shirt in the Global Economy.* New Jersey: John Wiley & Sons, Inc.

Rogers, Everett. 2003. *Diffusion of Innovations.* New York: Simon & Schuster, Inc.

Singh, Santosh. 2015. "Agricultural Biotechnology Annual." *USDA Foreign Agricultural Service GAIN Report.* Report Number: IN5088: July 10, 2015.

Smale, Melinda, Patricia Zambrano, Guillaume Gruere, Jose Falck-Zepeda, Ira Matuschke, Daniela Horna, Latha Nagarajan, Indira Yerramareddy, Hannah Jones. 2009. *Measuring the Economic Impacts of Transgenic Crops in Developing Agriculture During the First Decade.* Washington D.C.: International Food Policy Research Institute.

Sood, Dhruv. 2015. "Cotton and Products Annual." *USDA Foreign Agricultural Service GAIN Report.* Report Number: IN5039: March 30, 2015.

Shrinivasan, Rukmini. 2013. "Farmer Population Falls by 9 Million in 10 Years". *The Times of India*. http://timesofindia.indiatimes.com/india/Farmer-population-falls-by-9-million-in-10-years/articleshow/19813617.cms

Stewart, Scott. 2007. "Bt Cotton". *University of Tennessee Extension.* http://www.utcrops.com/cotton/cotton_insects/pubs/W129-BtCotton.pdf

Stone, Glenn Davis. 2012. "Constructing Facts." *Economic & Political Weekly* 47 (38): 63.

Stone, Glenn Davis, Andrew Flachs, and Christine Diepenbrock. 2014. "Rhythms of the Herd: Long Term Dynamics in Seed Choice by Indian Farmers." *Technology in Society* 36 (February): 26–38. doi:10.1016/j.techsoc.2013.10.003.

Stone, Glenn Davis. 2011. "Field Versus Farm in Warangal: Bt Cotton, Higher Yields, and Larger Questions." *World Development* 39 (3): 387–98. doi:10.1016/j.worlddev.2010.09.008.