The social and economic context of glyphosate-tolerant weeds in Londrina, PR and surrounding municipalities

MITTELBERG, T.[1]; MORAES, A. S.[2]
[1]UEL, Comissão Fulbright Brasil, tmittelberg1@gmail.com; [2]Pesquisador, Embrapa Soja, Londrina, PR

Resumo

Embora as plantas daninhas resistentes aos herbicidas possam aparecer em qualquer sistema de cultivo, aqueles com cultivares transgênicas resistentes ao glifosato (RR) são especialmente suscetíveis às plantas daninhas resistentes porque a simplicidade de aplicação desestimula os produtores a fazerem rotação de herbicidas (Bennett, 2007). No Brasil, existem oito espécies de plantas daninhas resistentes ao glifosato e o custo de seu controle é de R$4.9 bilhões por ano (Adegas et al., 2017; Heap, 2018). A medida que as plantas daninhas desenvolvem resistência mais rapidamente do que os cientistas conseguem desenvolver novos pesticidas, pesquisadores exigem um melhor entendimento das barreiras aos métodos de controle sustentáveis nas fazendas (Borel, 2018). Com questionários e entrevistas semiestruturadas, este estudo caracterizará como os produtores em Londrina, PR e nos municípios próximos decidem quais métodos de controle de plantas daninhas implementar, com foco em como são analisadas as recomendações das várias fontes de assistência técnica. Este estudo também pretende ilustrar como os produtores conceituam as consequências, de longo e de curto prazos, da prevenção da evolução da resistência aos herbicidas. Este estudo mostrará as oportunidades e desafios de como os produtores usam os transgênicos, contribuindo para a discussão sobre a melhor forma de usar biotecnologia agrícola no Brasil e no mundo.

Introduction

As the Green Revolution of the mid-20th century dramatically improved agricultural productivity and reduced rural poverty in Asia and Latin America, many wondered what it would take to spark a similar transformation in Africa.

In the 1980s and 90s, breakthroughs in biotechnology presented an intriguing possibility: genetically engineering a crop to improve its yield, resistance to disease, or nutritional value. Because the technology was contained in the DNA of the seed, these new genetically engineered (GE) crops would require no special inputs or technical knowledge to cultivate. The Food and Agriculture Organization of the United Nations (FAO) speculated that a “Gene Revolution” could uplift those farmers whom the Green Revolution had ignored (Paarlberg, 2005).

GE crops soon became ubiquitous in such high- and middle-income countries as the United States, Brazil and Argentina, increasing yields and decreasing production costs of primarily commodity crops such as maize, soybean, and cotton. In the developing world, scientists have developed numerous GE crops to alleviate food insecurity and rural poverty (for example, beta-carotene-enriched rice in the Philippines, disease-resistant banana in Uganda, insect-resistant cowpea in Ghana); however, few crops engineered specifically for resource-poor farmers have left the greenhouse in part due political and economic barriers to the commercialization of agricultural biotechnology. First, establishing proper biosafety laws can take years and requires cross-sector cooperation, government and public support of transgenic crops, and significant human resources (Cohen, 2001). Once established, the risk assessments and research permits mandated by these regulations help avert risks to human and environmental health; however, the time and cost required to comply with them can hinder trait developers working for resource-poor institutions such as universities, government research institutions, small seed companies, and NGOs (Spielman, 2007). Multinational private companies can afford to undertake these regulatory procedures for such profitable traits as insect resistance, drought resistance and herbicide resistance, and for such cash crops as maize, cotton and soybean. However, they are unlikely to invest in the development of traits that only benefit smallholders because these projects are less profitable.

To confront these institutional barriers, scientists and lawmakers in developing countries often look abroad to successful biotechnology programs as models for establishing their own technical and regulatory capacities. And in both popular and academic literature, experts often cite Brazil as one such model, largely due to its effective biosafety regulatory system and consistent investment in public agricultural innovation at both the state and national levels (Cornish, 2018; Gray; Dayananda, 2014; Pray; Naseem, 2003). The Brazilian Agricultural Research Corporation (Embrapa) in particular has become a global leader in public biotechnology research, leading the development of such GE crops as golden mosaic-resistant bean, approved in 2011, and cane-borer-resistant sugarcane, approved by CNTBio in 2017 with expected commercialization within five years (Aragão, 2014; Mano, 2017). In addition to a robust public sector, Brazil also has significant private-sector investment and collaboration in R&D by such companies as Monsanto, Bayer, BASF, and Syngenta. These international agribusinesses (many of which have recently merged or acquired by other companies) are particularly dominant in soybean production (Rhodes, 2014). Economist Carl Pray argues that this incentivization of private and public R&D sets Brazil apart from other middle-income biotechnology giants like India and China, making it a particularly strong model for other countries establishing R&D infrastructure (Pray, 2001).

As a whole, the literature suggests that Brazilian policymakers have mitigated common high-level economic and institutional barriers to biotechnology through generous public funding of R&D, partnerships with private companies, and an effective biosafety regulatory system. However, fewer studies characterize the structural challenges of the Brazilian biotechnology innovation system at the level of the farmers, seed vendors, and technical assistants. The experiences of these end-users can explain the ultimate effectiveness of a technology and point to systemic problems that are not necessarily obvious from a policy or macroeconomic lens.

One of the primary challenges of farmers around the world is weed control, particularly controlling those that have evolved tolerance to herbicides. While herbicide-resistant weeds are not unique to cropping systems with GE glyphosate-resistant (GR) crops, these cropping systems are particularly prone to herbicide-tolerant weeds because the ease of application discourages producers from rotating pest-control practices (Bennett, 2007). In fact, 90% of infested areas and economic losses due to herbicide-tolerant weeds are a result of glyphosate-tolerant weeds in GR cropping systems (Heap; Duke, 2017). In Brazil, there are eight species of glyphosate-tolerant weeds, and controlling herbicide-resistant weeds costs Brazil up to an estimated R $4.9 billion (USD $1.3 billion) per year (Adegas et al., 2017; Heap, 2018). Basic agronomy and ecology assert that the most effective way to slow the evolution of tolerance is by seasonally rotating weed management practices (Edwards et al., 2014); however, many farmers fail to implement these preventative measures, suggesting that there are systemic, economic and/or educational barriers that limit the responsible use of technology. It is important to unders-tand the sociopolitical systems under which herbicide resistance evolves in order to implement solutions at the farm, community, and national levels, yet to date, few such studies have been conducted (Ervin; Jussaume, 2014).

In Londrina, Paraná and its surrounding municipalities, there is consensus among trait developers and technical assistants that the misuse of Roundup-Ready crops is not inherent to the technology itself. Rather, farmers over apply herbicides because of much of the technical advice that they receive comes from assistants incentivized to sell herbicides, a result of agrochemical companies having more resources to deploy field staff than such agencies as agricultural cooperatives, private consultants and research foundations. The first goal of this study is to characterize producer-vendor relationships to support, qualify, or deny the assumption that vendors play an outsized role in the implementation of biotechnology in northern Paraná.

As weeds evolve resistance more quickly than scientists can develop new pesticides, researchers are urging for a greater understanding of the farm--level barriers to sustainable weed management practices (BOREL, 2018). The second goal of this study is to understand how producers in the Londrina area conceptualize short-term and long-term costs and benefits of herbicides to aid in the development of educational outreach promoting sustainable pest control.

Methodology

Data will be collected through surveys and semi-structured interviews with producers and other actors. In the first stage of the study, surveys will be conducted with 50 producers to establish the basic “if,” “who,” “what,” “where,” and “when” of their interactions with herbicide vendors. For example, the sur-vey contains questions about whether they interact with door-to-door vendors and if so, who initiates the sale, what types of technical advice they receive, whether the sale takes place on-farm or at agrodealer shops (“revendas”), and how often producers purchase vendors' products. The surveys ask similar questions about each producer's interactions with non-vendor technical assistants to allow for comparison. The results from this portion of the project will suggest whether or not economic bias in the technical assistance system discourages the use of agricultural best practices. These surveys also contain general questions about which practices the producer uses to prevent the evolution of resistance, for how long s/he has used that practice, and whether his/her neighbor uses similar practices.

After the survey stage of the study, semi-structured interviews will be conducted with producers to understand why and how they decide which pest control practices to implement. Producers will be asked about their decision-making processes, urging them to go into greater depth about how they decide which sources of technical assistance are trustworthy and how they choose what to do if they receive conflicting recommendations from different sources. The interviews will also be an opportunity to ask farmers about how they view the short-term and long-term consequences of various pest-control practices.

Finally, semi-structured interviews will be conducted with other actors involved in the development and commercialization of Roundup-Ready soybean to understand their perceived roles in the evolution of herbicide-resistant weeds. The exact nature of these interviews will depend on the results of the producer interviews and surveys.

Development

At the time of submission of this abstract, there has not been a sufficient quantity of surveys or interviews conducted to report significant results. However, from initial surveys and conversations with producers, a few trends appear to be emerging:

As producers decide whether or not to implement a pest control practice, they weigh a variety of factors including the cost of implementation, past experience with that practice, their trust in the technical assistant that recommended it, and advice from neighbors, relatives, and other technical assistants. Many of the producers surveyed so far have indicated that their trust in the source of technical advice is the most important factor when deciding whether to implement a practice - but only when that source is the cooperative. Producers who also receive technical advice from agrochemical vendors report that their trust in the source plays a less important role in their decision-making process. Additionally, producers reported nearly universally that cooperative agronomists gave feedback after the implementation of the recommended practice, whereas few producers received feedback from vendors.

Most producers (>95%) surveyed implement at least one strategy for preventing the evolution of herbicide-tolerant weeds, and many employ multiple. The most commonly employed strategies have been removing weeds by hand, herbicide rotation, and crop rotation.

Most producers have reported that vendors visit their property selling herbicides, and most have purchased their products in the past five harvests. As they answered the survey questions about the vendors, several producers expressed that they found these visits annoying (interestingly, some of these producers reported purchasing from the vendors within the past five years anyways). A majority of producers who purchased from vendors said that they would do so again.

Considerations

The outcomes of the use of a biotechnology vary by locality, trait, and cropping system. However, individual and community-level case studies can reveal universal lessons for managing herbicide resistance and other environmental externalities of biotechnology. In the Londrina area, researchers and technical assistants blame agrochemical vendors for pressuring producers to adopt herbicide-heavy pest control systems instead of an integrated approach. The prominent role of the private sector in the biotechnology industry is irrefutable even in Brazil, which is internationally lauded for its public agricultural research system. Transgenic crops are inherently more expensive to commercialize due to high costs of intellectual property, trait development and deregulation (Spielman, 2007). As a result of these expenses, only a limited number of crops and traits are financially viable to develop, and those that reach commercialization must be aggressively marketed in order to be profitable. Should herbicide vendors in Paraná play an outsized role in farmer decision-making processes (as local agronomists suggest), this case study will provide an example of an environmental consequence of such marketing. Extension agents and policymakers should be aware of this economic context as they develop outreach programs to promote sustainable pest control practices.

If one imagines every technology present in a GR cropping system - from the seed, to the sprayer, to the herbicide itself - one realizes that a single soybean field represents the contributions of countless individuals including trait developers, breeders, lab assistants, chemists, mechanical engineers, regulators, patent writers, corporate strategists, market analysts, advertisers, distributors, agronomists, vendors, and ultimately, farmers. According to the psychological theory of the diffusion of responsibility, individuals are more likely to take risks when they perceive that negative consequences of the risk will be distributed across a group of people (Wallach; Kogan; BEM, 1964). This theory is useful for explaining why it is so challenging to address herbicide-tolerant weeds: with so many actors responsible for the design and implementation of GR cropping systems, there is little individual accountability for such negative outcomes. Furthermore, individual actors are less likely to urgently address their own role in perpetuating a negative outcome when they perceive that they are not the only ones responsible.

As scientists and extension agents develop new solutions to weed control, it will be important to understand how underlying social systems prevent or promote the responsible use of biotechnology. This study will illustrate the strengths and limitations of how farmers implement GM crops, contributing to larger conversations on how to best use agricultural technology in Brazil and around the world.

Acknowledgements

Thank you to the anonymous reviewers for providing valuable feedback for this abstract. Thank you to Fernando Storniolo Adegas, Divânia de Lima, Arnold Barbosa de Oliveira, André Mateus Prando, Fernando Augusto Henning, and Elemar Voll for your valuable technical insight and assistance with survey design. Many thanks to the managers, technical assistants, and agronomists of the Integrada and Cocamar agricultural cooperatives for hosting me as I conducted surveys. Finally, thank you to the producers who provided their time and knowledge to participate in this study.

References

ADEGAS, F. S.; VARGAS, L.; GAZZIERO, D. L. P.; KARAM, D.; SILVA, A. F. da; AGOSTINETTO, D. **Impacto econômico da resistência de plantas daninhas a herbicidas no Brasil**. Londrina: Embrapa Soja, 2017. 11 p. (Embrapa Soja. Circular técnica, 132).

ARAGÃO, F. J. L. GM plants with RNAi: golden mosaic resistant bean. **BMC Proceedings**, v.8, suppl, p. 24-25, 2014. (Open access) Edição do Congress of the Brazilian Biotechnology Society, Florianópolis, 2013.

BENNETT, D. Ian Heap helps keep tabs on global weed resistance. **Delta Farm Press**, Irving, TX, jan. 2007. Disponível em: <http://www.deltafarmpress.com/ian-heap-helps-keep-tabs-global-weed-resistance>. Acesso em: 2 jul. 2018.

BOREL, B. Weeds are winning in the war against herbicide resistance. **Scientific American**, New York, jun. 2018. Disponível em: <https://www.scientificamerican.com/article/weeds-are-winning-in-the-war-against-herbicide-resistance/>. Acesso em: 19 jun. 2018.

COHEN, J. I. Harnessing biotechnology for the poor: challenges ahead for capacity, safety and public investment. **Journal of Human Development**, v. 2, n. 2, p. 239-262, 2001.

CORNISH, L. What are the political drivers for GMOs in developing countries? **Devex**, Washington, D.C., mai. 2018. Disponível em: <https://www.devex.com/news/sponsored/what-are-the-political-drivers-for-gmos-in-developing-countries-92091>. Acesso em: 4 jun. 2018.

EDWARDS, C. B.; JORDAN, D. L.; OWEN, M. D. K.; DIXON, P. M.; YOUNG, B. G.; WILSON, R. G.; WELLER, S. C.; SHAW, D. R. Benchmark study on glyphosate-resistant crop systems in the United States: economics of herbicide resistance management practices in a 5 year field-scale study. **Pest Management Science**, v. 70, n. 12, p. 1924-1929, 2014.

ERVIN, D.; JUSSAUME, R. Integrating social science into managing herbicide-resistant weeds and associated environmental impacts. **Weed Science**, v. 62, n. 2, p. 403-414, 2014.

GRAY, R.; DAYANANDA, B. Structure of public research. In: SMYTH, S. J.; PHILLIPS, P. W. B.; CASTLE, D. (Eds.). **Handbook on Agriculture, Biotechnology and Development**. Cheltenham, UK: Edward Elgar Publishing, 2014. p. 36-55.

HEAP, I. **The international survey of herbicide resistant weeds**. Disponível em: <http://www.weedscience.org>. Acesso em: 5 jun. 2018.

HEAP, I.; DUKE, S. O. Overview of glyphosate-resistant weeds worldwide. **Pest Management Science**, v. 74, n. 5, p. 1040-1049, 2017.

MANO, A. Brazil approves world's first commercial GM sugarcane: developer CTC. **Reuters,** São Paulo, 8 jun. 2017. Disponível em: <https://www.reuters.com/article/us-brazil-sugar-gmo/brazil-approves-worlds-first-commercial-gm-sugarcane-developer-ctc-idUSKBN18Z2Q6>. Acesso em: 2 jul. 2018.

PAARLBERG, R. From the green revolution to the gene revolution. **Environment**, v. 47, n. 1, p. 38-40, 2005.

PRAY, C. E. Public-private sector linkages in research and development: biotechnology and the seed industry in Brazil, China and India. **American Journal of Agricultural Economics**, v. 83, n. 3, p. 742-747, 2001.

PRAY, C. E.; NASEEM, A. **Biotechnology R&D: policy options to ensure access and benefits for the poor**. Rome: FAO, 2003. 37 p. (ESA Working Paper, 03-08).

RHODES, S. D. South American adopters: Argentina and Brazil. In: SMYTH, S. J.; PHILLIPS, P. W. B.; CASTLE, D. (Eds.). **Handbook on Agriculture, Biotechnology and Development**. Cheltenham, UK: Edward Elgar Publishing, 2014. p. 86-98.

SPIELMAN, D. J. Pro-poor agricultural biotechnology: can the international research system deliver the goods? **Food Policy**, v. 32, n. 2, p. 189-204, 2007.

WALLACH, M. A.; KOGAN, N.; BEM, D. J. Diffusion of responsibility and level of risk taking in groups. **The Journal of Abnormal and Social Psychology**, v. 68, n. 3, p. 263-274, 1964.