2014

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Susan Johnson

Sustainable Development Law & Policy

Volume 14 | Issue 1 Article 6

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American University Washington College of Law

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*By Susan Johnson**

Genetically modified organisms ("GMOs") entered the commercial marketplace in the early 1990s with the introduction of the infamous yet ill-fated Flavr Savr tomato.[1] Since then, scientists, scholars, journalists, and consumers have debated GMO safety and sustainability. On one side of the argument are those who maintain that extensive scientific research and regulatory endorsement from entities such as the National Academy of Sciences and the U.S. Food and Drug Administration has established the safety and integrity of GMOs.[2] On the other side are those who cite lingering scientific uncertainty, environmental burdens, and mistrust of the biotech industry generally.[3] These opponents to GMOs point to the multitude of concepts and products once thought safe and scientifically sound that ultimately proved anything but, such as tobacco and DDT.[4] Still, despite this persistent debate over the virtue of genetically engineered food sources, their prevalence in the U.S. food system continues to increase.[5] It is therefore crucial that thorough analysis of GMO safety and sustainability continues until more questions are answered.

Genetic modification ("GM") is the alteration of an organism's DNA through the synthetic introduction of new traits that allow manufacturers increased control over genetic structures, purportedly strengthening the final product's viability and appeal.[6] In turn, GMO seeds appeal to farmers for their promise of economically beneficial higher crop yields.[7] Consumers may similarly benefit, as engineered fruits and vegetables are created to have longer shelf lives and smaller price tags than their unaltered counterparts.[8] Given the fact that U.S. biotech companies produce approximately half of the world's GMO crop seeds,[9] generating billions of dollars in annual revenue,[10] the biotech industry has much to gain from scientific confirmation and public acceptance of these purported "benefits."

Despite persistent skepticism, GMOs dominate the domestic market, largely due to powerful initiatives that insulate the industry.[11] Independent scientists who publish studies showing negative or abnormal phenomena implicating GM products have frequently endured criticism and backlash from scientific peers working to preserve GMO-friendly public policies.[12] In this climate of debate, members of the biotech field aggressively defend industry practices and relentlessly contest any perceived opposition or legal violation. Industry giant Monsanto, for example, has sued more than 410 farmers in twenty-seven states,[13] in some instances destroying multi-generational farms in the process.[14] By contrast, anti-GMO activists have comparatively fewer and less powerful legal mechanisms at their disposal, limiting the ubiquity of their critical message.[15]

Recently, the decades-old GMO debate has flared again with the introduction of "Golden Rice," a genetically modified strain of rice intended to combat worldwide hunger and disease.[16] Articles in The New York Times, Forbes, and Slate (among others) have featured the controversial product, prompting supporters and opponents to reassert their positions on GMOs in a new context.[17] Golden Rice is fortified with the Vitamin A precursor beta-carotene, and its creators assert that it will save countless lives and combat malnutrition and disease on an unprecedented global scale.[18] Beta-carotene is a powerful nutrient found in fruits and vegetables such as carrots, sweet potatoes, and spinach that strengthens the immune system, protects and improves vision and dental health, and delivers cancer-fighting antioxidants.[19] Vitamin A deficiency significantly compromises the immune system and causes blindness in up to half a million children each year.[20] Alarmingly, millions of people in Africa and Asia who lack this nutrient die annually from diseases to which they would not otherwise be susceptible.[21] Golden Rice skeptics view it as a wolf in sheep's clothing—a way for biotech companies to further infiltrate the global agricultural marketplace under an altruistic guise with little regard for broader human health and environmental impacts.[22] Activists urge that the real purpose of Golden Rice is to gain widespread public support for GMO crops, ultimately producing a windfall for biotech corporations to the detriment of farmers and consumers.[23] They bolster this assertion by questioning Golden Rice's viability,[24] emphasizing that target African consumers do not traditionally eat rice[25] and that many of the countries that purportedly stand to benefit have stringent anti-GMO policies.[26]

Further criticism is aimed at the unsustainability of GMO crops.[27] For farmers to maintain optimal production they must apply powerful pesticides, which are genetically modified to resist the chemicals.[28] This unnatural cycle has the potential to create "super pests" and "super weeds" that may threaten traditional crop varieties and alter the soil's chemical composition.[29] Though it is difficult to ascertain how extensive or lasting the damage from these cycles will be, many argue that this uncertainty alone is reason enough to proceed with caution (if at all).[30]

With the spread of GMO-sourced crops into the human food chain, a growing number of consumers and activists who oppose GMO proliferation are using every legal, regulatory, and grassroots tool at their disposal to slow the trend.[31] In August 2013, farmers and environmental activists destroyed an experimental plot of Golden Rice in the Philippines in protest.[32] Domestically,

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* *J.D. Candidate 2014, American University Washington College of Law*

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opponents are demonstrating their will in the courtroom, at the polls, and in the marketplace.[33] The growing GMO labeling movement is a major source of local and national activism. Voters in California and Washington voted to overcome significant resistance by corporations that fear GMO labeling, despite the fact that those entities label their products in 64 other countries around the world.[34] Monsanto and others have spent $22 million to defeat the Washington labeling initiative, the most ever spent to defeat a ballot initiative in the state's history.[35] In 2013, twenty-six additional states introduced similar GMO labeling legislation.[36] It remains to be seen if the biotech industry will overcome these efforts with its deep pockets,[37] inestimable legal resources, and political muscle.[38]

The resurgence of the GMO debate following the introduction of Golden Rice indicates that the argument is far from settled. Questions remain as to the long-term safety and sustainability of genetically modified products, generally, and the ability of Golden Rice, specifically, to effectively impact the global hunger epidemic without significant ecological consequences. History has taught us that informed skepticism has the power to inform society, protect consumers, and preserve the environment. Before Golden Rice is allowed unfettered access to the global marketplace, escalating the proliferation of GM food sources, the long-term safety and environmental sustainability of genetic modification should be further analyzed to prevent irreparable consequences.

Endnotes: Genetically Modified Food: A Golden Opportunity?

1 *See* Clive James, Global Review of the Field Testing and Commercialization of Transgenic Plants: 1986 to 1995, at v (1996) *available at* http://www.isaaa.org/kc/Publications/pdfs/isaaabriefs/Briefs%201.pdf.

2 *See* Jon Entine, *No, You Shouldn't Fear GMO Corn*, Slate (Aug. 7, 2013), http://www.slate.com/articles/health_and_science/science/2013/08/can_gmo_corn_cause_allergies_don_t_believe_elle_s_scary_story.single.html; *see also* American Association for the Advancement of Science, Statement by AAAS Board of Directors on Labeling of Genetically Modified Foods 1 (Oct. 2012), *available at* http://www.isb.vt.edu/news/2013/Mar/AAASBoard.pdf.

3 *See* Sasha J. Wright, *Why The GMO Debate Misses the Point*, Popular Sci. Biohackers Blog (Oct. 29, 2013 10:32 AM), http://www.popsci.com/blog-network/biohackers/why-gmo-debate-misses-point?dom=PSC&loc=recent&lnk=2&con=IMG; *see also* Beth Hoffman, *Just Because Science Can Genetically Engineer Foods, Doesn't Mean We Should* (Aug. 26, 2013), http://www.forbes.com/sites/bethhoffman/2013/08/26/why-genetically-modifying-food-is-a-bad-idea/.

4 Hoffman, *supra* note 3.

5 *See* International Service for the Acquisition of Agro-Biotech Applications, ISSAA Brief 43-2011: Executive Summary, *available at* http://www.isaaa.org/resources/publications/briefs/43/executivesummary/default.asp.

6 *See* Carl K. Winter & Lisa K. Gallegos, Univ. of Cal. Dep't of Agric. & Natural Res., Safety of Genetically Modified Food 1 (2006), *available at* http://anrcatalog.ucdavis.edu/pdf/8180.pdf.

7 Tom Philpott, *Do GMO Crops Really Have Higher Yields?*, Mother Jones (Feb. 13, 2003), http://www.motherjones.com/tom-philpott/2013/02/do-gmo-crops-have-lower-yields; Robin Vinter, US Farmers May Stop Planting GMs After Poor Global Yields, Farmer's Weekly (Feb. 6, 2013), http://www.fwi.co.uk/articles/06/02/2013/137518/us-farmers-may-stop-planting-gms-after-poor-global-yields.htm.

8 *See 20 Questions on Genetically Modified Foods*, World Health Organization, http://www.who.int/foodsafety/publications/biotech/20questions/en/.

9 *See U.S. and Monsanto Dominate Global Market for GMO Seeds*, Organic Consumers Ass'n (Aug. 7, 2013), http://www.organicconsumers.org/articles/article_28059.cfm.

10 Monsanto Co., Monsanto 2012 Annual Report 40, *available at* http://www.monsanto.com/investors/Documents/Annual%20Report/2012/monsanto-2012-annual-report.pdf.

11 *See* Emily Waltz, *GM Crops: Battlefield* (Sept. 2, 2009), http://www.nature.com/news/2009/090902/full/461027a.html.

12 *Id.*

13 The Ctr. for Food Safety & Save Our Seeds, Seed Giants vs. U.S. Farmers 6-7, *available at* http://www.centerforfoodsafety.org/files/seed-giants_final_04424.pdf.

14 Kristine Lofgren, *Monsanto Has Sued Hundreds of Small Farmers, Heads to the Supreme Court*, Inhabit (Feb. 13 2013), http://inhabitat.com/monsanto-has-sued-hundreds-of-small-farmers-heads-to-the-supreme-court/.

15 *New Poll Finds Widespread Support for GMO Labeling As New Hampshire House Committee Prepares to Vote on GMO Labeling Law*, Food Democracy Now! (Nov. 5, 2013), http://www.fooddemocracynow.org/blog/2013/nov/5/new_poll_finds_90_percent_NH_voters_loveGMO_labels/.

16 *Our Mission*, Int'l Rice Research Inst., http://www.irri.org/about-us/our-mission [hereinafter IRRI] (last visited Dec. 6, 2013).

17 Amy Harmon, Golden Rice: Lifesaver?, N.Y. Times, Aug. 23, 2013, http://www.nytimes.com/2013/08/25/sunday-review/golden-rice-lifesaver.html?_r=0; Entine, *supra* note 2; Hoffman, *supra* note 3.

18 Harmon, *supra* note 17.

19 *See Vitamins and Supplements Lifestyle Guide*, WebMD, http://www.webmd.com/vitamins-and-supplements/lifestyle-guide-11/supplement-guide-vitamin-a.

20 Harmon, *supra* note 17.

21 Harmon, *supra* note 17.

22 *See* Harmon, *supra* note 17.

23 Caroleanne Wright, *GM Golden Rice: Miracle or Menace? Top Activists Speak Out*, Natural News (Sept. 19, 2013), http://www.naturalnews.com/042124_golden_rice_gmos_activists.html. Furthermore, biotech giant Syngenta owns the patent for Golden Rice. While it claims the seeds will be available royalty free, legally Syngenta can change its position at any time. Golden Rice is a project of the International Rice Research Institute ("IRRI"), a nonprofit organization lead Dr. Gerard Barry, a twenty-year Monsanto veteran. Both Monsanto and GMO producer Syngenta contribute funding to IRRI. IRRI, *supra* note 16.

24 Beth Hoffman, *Golden Rice and GMOs: The Best Solutions To World Hunger?*, (Aug. 31, 2013), http://www.forbes.com/sites/bethhoffman/2013/08/31/golden-rice-and-gmos-the-best-solution-to-world-hunger/.

25 *Id.*; Afr. Rice Ctr., Africa Rice Trends 5 (2007), *available at* http://www.africarice.org/publications/Rice%20Trend%2023-10-07.pdf.

26 *Id.*; Ctr. for Food Safety, http://www.centerforfoodsafety.org/ge-map/ (last visited Dec. 6, 2013).

27 *See* Wright, *supra* note 23.

28 Jason Koebler, *Herbicide Resistant "Super Weeds" Increasing Plaguing Farmers*, U.S. News & World Report (Oct. 19, 2012), http://www.usnews.com/news/articles/2012/10/19/herbicide-resistant-super-weeds-increasingly-plaguing-farmers.

[29] *Id.*

[30] *Genetically Modified or Sustainable Agriculture?*, Greenpeace, http://www.greenpeace.org/eu-unit/en/campaigns/EU-farmers-ditch-GM-crops/.

[31] *See* Stephanie Strom, *Misgivings about How Weed Killer Affects the Soil*, N. Y. Times, Sept. 19, 2013, http://www.nytimes.com/2013/09/20/business/misgivings-about-how-a-weed-killer-affects-the-soil.html.

[32] *See* Harmon, *supra* note 17.

[33] Strom, *supra* note 31.

[34] *New Poll Finds Widespread Support for GMO Labeling as New Hampshire House Committee Prepares to Vote on GMO Labeling Law*, Food Democracy Now! (Nov. 5, 2013), http://www.fooddemocracynow.org/blog/2013/nov/5/new_poll_finds_90_percent_NH_voters_loveGMO_labels/.

[35] *Id.*

[36] *Id.*

[37] Tarini Parti & Jenny Hopkinson, *Monsanto, DuPont Pour Millions into GMO Fight*, Politico (Sept. 11, 2013), http://www.politico.com/story/2013/09/monsanto-dupont-pour-millions-into-gmo-fight-96643.html.

[38] Lindsay Boerma, *Critics Slam Obama for "Protecting" Monsanto*, CBS News (Mar. 28, 2013), http://www.cbsnews.com/news/critics-slam-obama-for-protecting-monsanto/.

Endnotes: Indonesia's Role in Realizing the Goals of ASEAN's Agreement on Transboundary Haze Pollution

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(last visited Feb. 21, 2013). Haze also contributes to "greenhouse gas and haze emissions from deforestation, land-use conflicts, loss of biodiversity, indigenous rights violations, pollution of waterways and the disruption of eco-systems." Jenny Marusiak, *Big Job ahead for Sustainable Palm Oil Group*, Eco-Business.Com, Oct. 31, 2012, http://www.eco-business.com/features/big-job-ahead-for-sustainable-palm-oil-group/. The U.S. Environmental Protection Agency ("EPA") defines regional haze as "visibility impairment that is produced by a multitude of sources and activities which emit fine particles and their precursors and which are located across a broad geographic area." Regional Haze Regulations, 64 Fed. Reg. 35714, 35715 (July 1, 1999) (to be codified at 40 C.F.R. pt. 51). Haze is further distinguished by the size of the particulate matter—PM2.5 is haze with particulates up to 2.5 microns wide, and PM10 is haze with particulates up to 10 microns wide. *See* Ahmad et al., *supra*. ASEAN is concerned with monitoring PM10. Ahmad et al., *supra*.

[16] *See* Ahmad et al., *supra* note 15; Alan Rogers, *Haze – Brown Clouds*, Borneo Post (Nov. 4, 2012), http://www.theborneopost.com/2012/11/04/haze-brown-clouds/ (explaining that low humidity means dry air which is stable and characterized by no horizontal or vertical air movement).

[17] *See* Ahmad et al., *supra* note 15; Rogers, *supra* note 16. On a clear day, ground visibility can extend up to seven miles. *Glossary: Visibility*, Weather Network, http://www.theweathernetwork.com/index.php?product=glossary&pagecontent=visibility (last visited Feb. 21, 2013).

[18] *See* Rogers, *supra* note 16 (noting that the variability of air pollution is affected by local meteorological conditions); Laura S. Henry et al., *From Smelter Fumes to Silk Road Winds: Exploring Legal Responses to Transboundary Air Pollution over South Korea,* 11 Wash. U. Global Stud. L. Rev. 565, 584 n.96 (2012) (citing World Health Org., The Health Risks of Particulate Matter from Long-Range Transboundary Air Pollution 1, 11 (2006), *available at* http://www.euro.who.int/__data/assets/pdf_file/0006/78657/E88189.pdf).

[19] *See* Regional Haze Regulations, *supra* note 15 (noting that visual impairment occurs because haze covers a broad geographical area); Merrill, *supra* note 10, at 970 (discussing the drifting nature of transboundary pollution).

[20] *See* Merrill, *supra* note 10, at 968 (defining transboundary air pollution).

[21] *See* Tom Ginsburg & Gregory Shaffer, *The Empirical Turn in International Legal Scholarship*, 106 Am. J. Int'l L. 1, 38 (2012).

[22] *Id.* (noting the varied effects of environmental regulation on states involved in the regulatory solution).

[23] *Id.* For an example dealing with ozone, see Jonathan Remy Nash & Richard L. Revesz, *Markets and Geography: Designing Marketable Permit Schemes to Control Local and Regional Pollutants*, 28 Ecology L.Q. 569, 599–601 (2001).

[24] *See* Ginsburg & Shaffer, *supra* note 21, at 38 (explaining the growing field of international environmental law and its extremely technical complexities).

[25] Ginsburg & Shaffer, *supra* note 21, at 38.

[26] *See* Merrill, *supra* note 10, at 970 (noting that transboundary pollution can be partial, unidirectional, or reciprocal, but usually has an impact on both the source and affected states).

[27] Merrill, *supra* note 10, at 970 (noting a source state will consider the cost of pollution incurred by its residents before adopting regulation).

[28] *See* Merrill, *supra* note 10, at 971 (referencing reciprocal pollution as when the pollution from A affects B and the pollution from B affects A).

[29] *See* Merrill, *supra* note 10, at 971. These characteristics, which Merrill refers to as "partial" and "reciprocal" transboundary pollution, are instrumental in his argument that transboundary pollution disputes should be governed by his "golden rules," which would allow affected states to apply the source state's liability rules against it. *Id*. Though this model may be attractive if it is restricted to norm creation in treaties, its emphasis on assigning liability may be a fatal defect if source states have not ratified the treaty. *Id*.

[30] The haze is an also an issue in other areas of ASEAN member states. *See, e.g.*, Kultida Samabuddhi, *Haze Returns to the North*, Bangkok Post, Feb. 27, 2012, http://www.bangkokpost.com/learning/easier-stuff/281819/haze-returns-to-the-north (discussing haze in Thailand's northern provinces); Wanwisa Ngamsangchaikit, *Haze the Next Threat*, TTR Weekly, Nov. 2, 2012, http://www.ttrweekly.com/site/2012/11/haze-the-next-threat/ (discussing haze's impact on tourism in North Thailand). It is likely that, as the region continues to industrialize and haze pollution increases overall, more transboundary haze issues will arise. *See, e.g.,* Alan Khee-Jin Tan, *The ASEAN Agreement on Transboundary Haze Pollution: Prospects for Compliance and Effectiveness Suharto Indonesia*, 13 N.Y.U. ENVTL. L.J. 647, 653–55 (2005); Gooch, *supra* note 4; Ahmad et al., *supra* note 15; Koh Kheng-Lian, *A Breakthrough in Solving the Indonesian Haze?*, *in* International Union for Conservation of Nature Environmental Law and Policy Paper No. 72 at 225 (Sharelle Hart ed., 2008) (blaming President Suharto's Mega Rice Project which attempted to turn one million hectares of peatland into rice paddies for potential increase in transboundary haze pollution).

[31] *See* Gooch, *supra* note 4 ("The haze, attributed mostly to fires burning on the Indonesian island of Sumatra, has become a recurring summer blight, engulfing parts of Malaysia, Thailand, Brunei and Singapore, and leaving a litany of health and economic costs in its wake.").

[32] *See infra* Part IV.A.

[33] *See* Khee-Jin Tan, *supra* note 30, at 653 (noting that Indonesia's common practice is to log an area and convert the land into a cash crop plantation).

[34] *See* Khee-Jin Tan, *supra* note 30 at 653. (explaining that logging involves removing the valuable tropical timber to make way for plantations).

[35] *See Indonesia*, UN-REDD Programme (2009), http://www.un-redd.org/CountryActions/Indonesia/tabid/987/language/en-US/Default.aspx (last visited Nov. 12, 2013) (noting Indonesia is the third largest area of tropical rainforest in the world). For more on the problem tropical deforestation poses from a climate change perspective, see William Boyd, *Ways of Seeing in Environmental Law*, 37 Ecology L.Q. 843 (2010).

[36] Peatlands are important for maintaining biological diversity and storing carbon. *See Values of Peatlands in Indonesia,* Sustainable Mgmt. of Peatland Forests in Se. Asia, http://www.aseanpeat.net/index.cfm?&menuid=128&parentid=68 (last visited Feb. 21, 2013); *Fact Sheet Norway-Indonesia Partnership REDD+*, http://www.norway.or.id/PageFiles/404362/FactSheetIndonesiaPeatMay252010.pdf (last visited Feb. 21, 2013).

[37] *See Values of Peatlands in Indonesia*, *supra* note 36 (noting that Indonesia emits about five times as much carbon dioxide yearly from degraded peatlands as it does burning fossil fuels).

[38] *See* Andrew C. Revkin, *The Fire Down Below*, N.Y. Times Dot Earth Blog, Aug. 20, 2010, 12:01 PM, http://dotearth.blogs.nytimes.com/2010/08/20/the-fire-down-below/ (referring to this underground burn as smoldering fires, which have been reported in boreal, temperate, and tropical forests). For a domestic example, see Willie Drye, *Vast Peat Fire may Burn for Months in North Carolina*, Nat'l Geographic News, June 13, 2008, http://news.nationalgeographic.com/news/2008/06/080613-wildfire-peat.html. Greenpeace