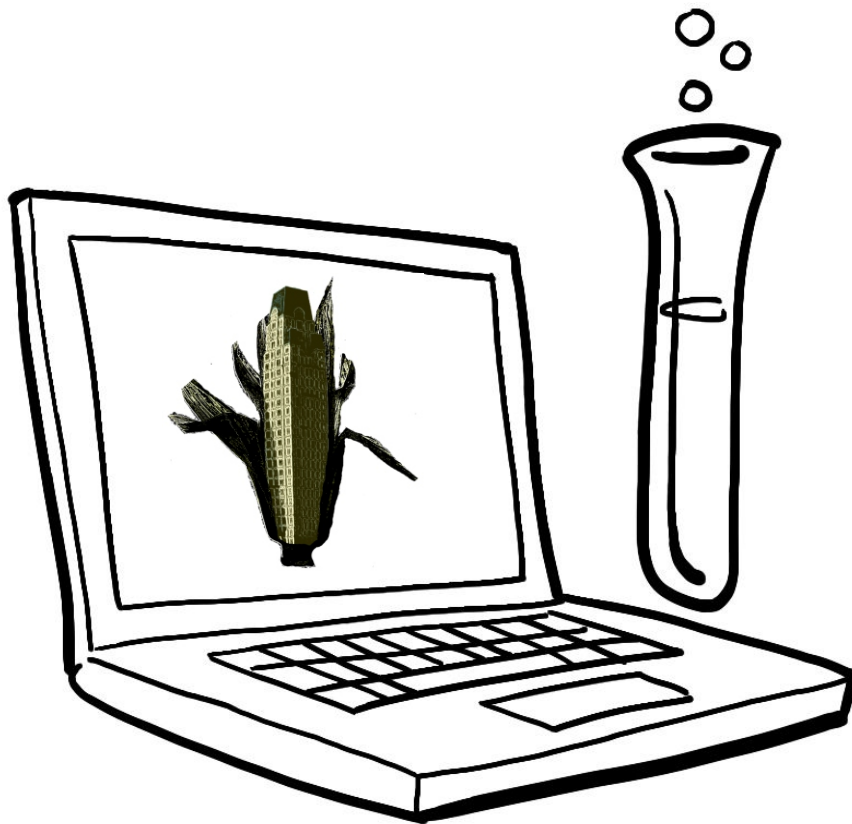


FEEDING NINE BILLION: THE ROLE OF SCIENCE AND TECHNOLOGY



[HTTP://WWW.FEEDINGNINEBILLION.COM/](http://www.feedingninebillion.com/)

**HELLO, MY NAME IS EVAN FRASER AND I WORK
AT THE UNIVERSITY OF GUELPH
IN ONTARIO CANADA.**



**THIS IS PART OF A SERIES ON HOW TO FEED
THE WORLD'S GROWING POPULATION.**

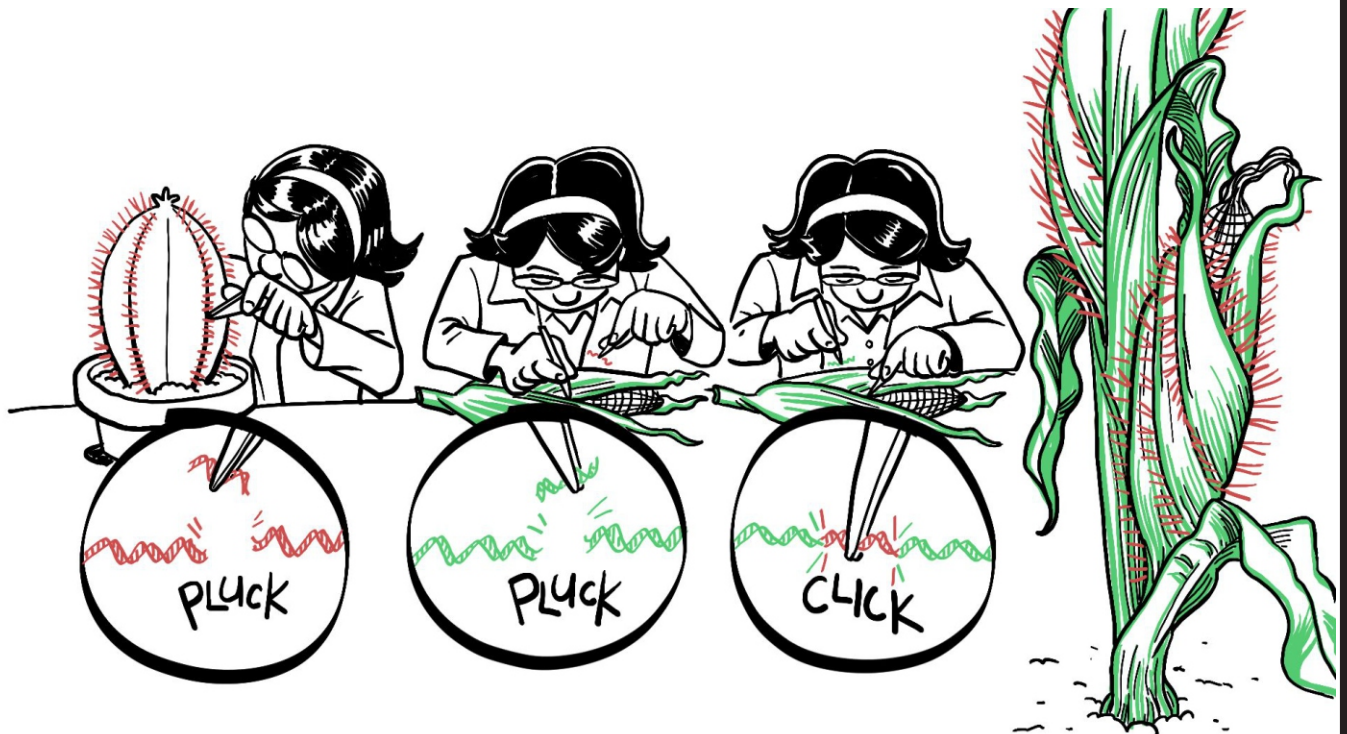
**UNIVERSITY
of GUELPH**

**CHANGING LIVES
IMPROVING LIFE**

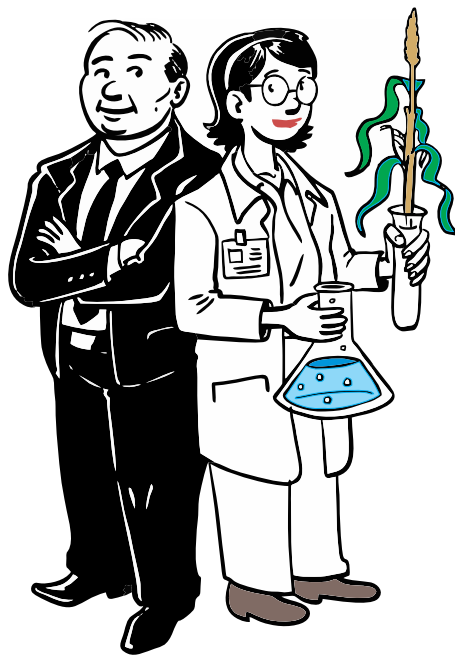
ONE OF THE MOST CONTROVERSIAL ASPECTS OF THE FOOD SYSTEM TODAY IS BIOTECHNOLOGY.

ONE TYPE OF BIOTECHNOLOGY IS CALLED GENETIC MODIFICATION AND HAPPENS WHEN SCIENTISTS MANIPULATE A PLANT'S (OR ANIMAL'S) DNA.

THIS CAN HAPPEN IN A NUMBER OF WAYS.



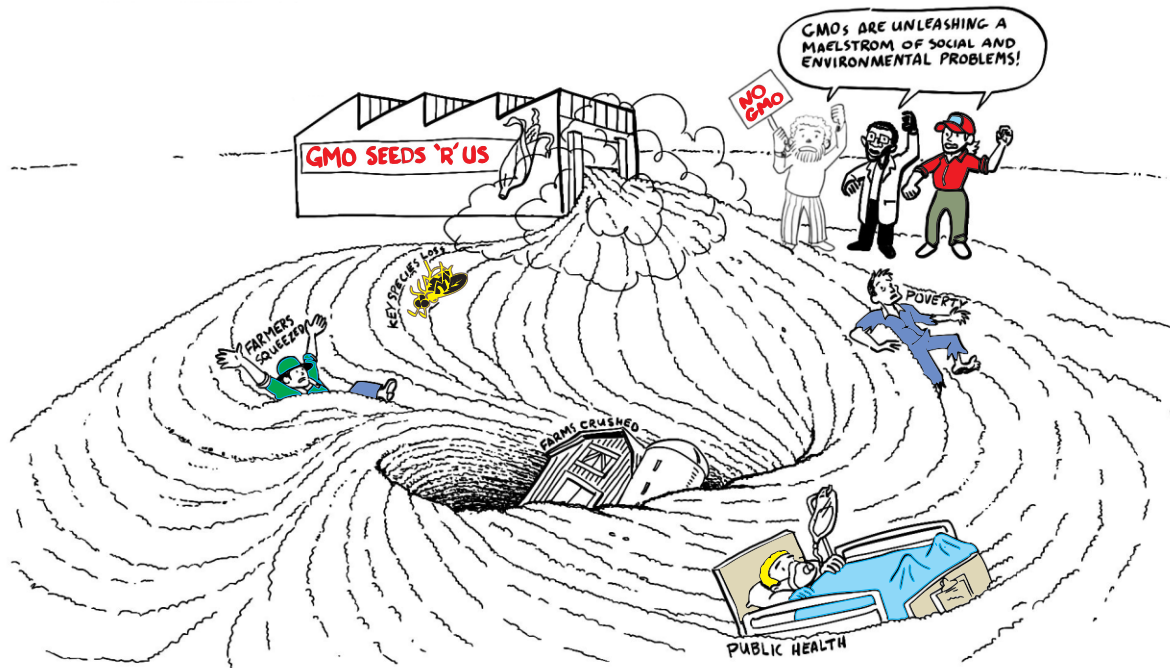
FOR INSTANCE, A SCIENTIST MAY MOVE A GENE FROM ONE SPECIES TO ANOTHER IN ORDER TO GIVE THE ORIGINAL ORGANISM SOME SPECIAL TRAIT SUCH AS THE ABILITY TO WITHSTAND DROUGHT¹.



Biotechnology

SUPPORTERS THINK CREATING GENETICALLY MODIFIED ORGANISMS - OR GMOs - IS NECESSARY TO ENSURE OUR CROPS ARE PRODUCTIVE AND RESILIENT ENOUGH TO PROVIDE ADEQUATE FOOD IN THE FUTURE².

OTHERS THINK GMOs ARE UNLEASHING A RANGE OF SERIOUS SOCIAL AND ENVIRONMENTAL PROBLEMS³.

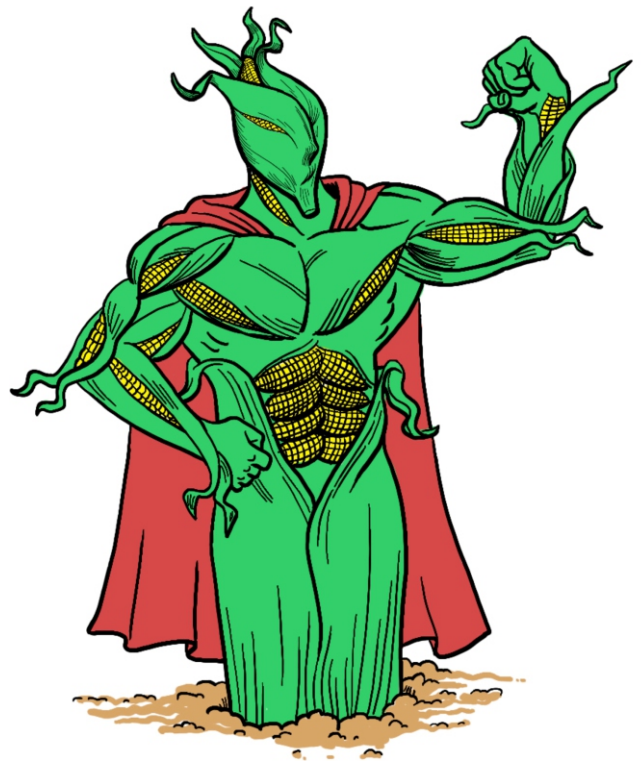




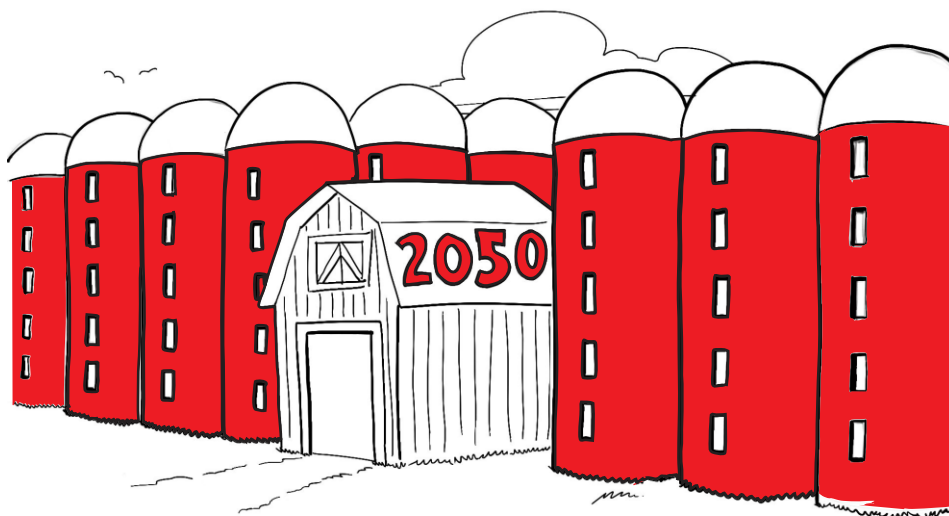
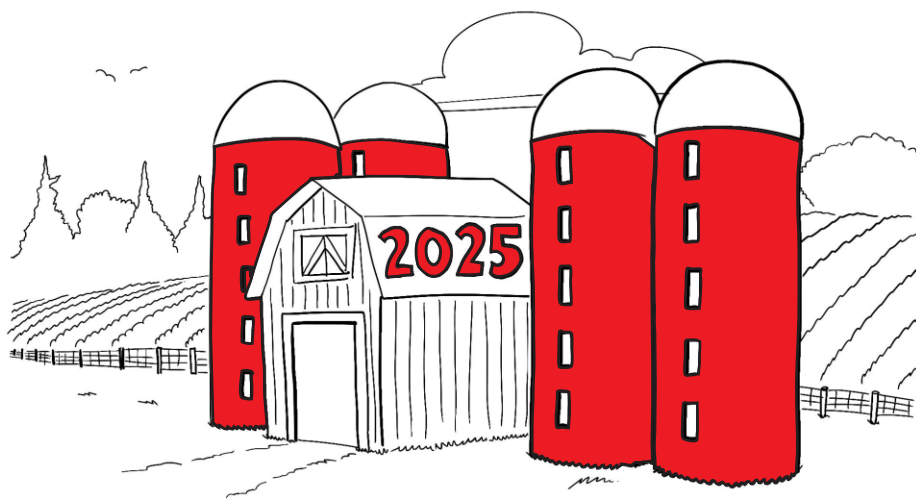
LET'S START WITH THE ARGUMENTS IN FAVOUR OF GMOS. SOME SCIENTISTS CLAIM THAT GMOS WILL ALLOW US TO CREATE NEW SUPER CROPS



. . . . THAT WILL BE 50% MORE PRODUCTIVE THAN CURRENT ONES⁴.

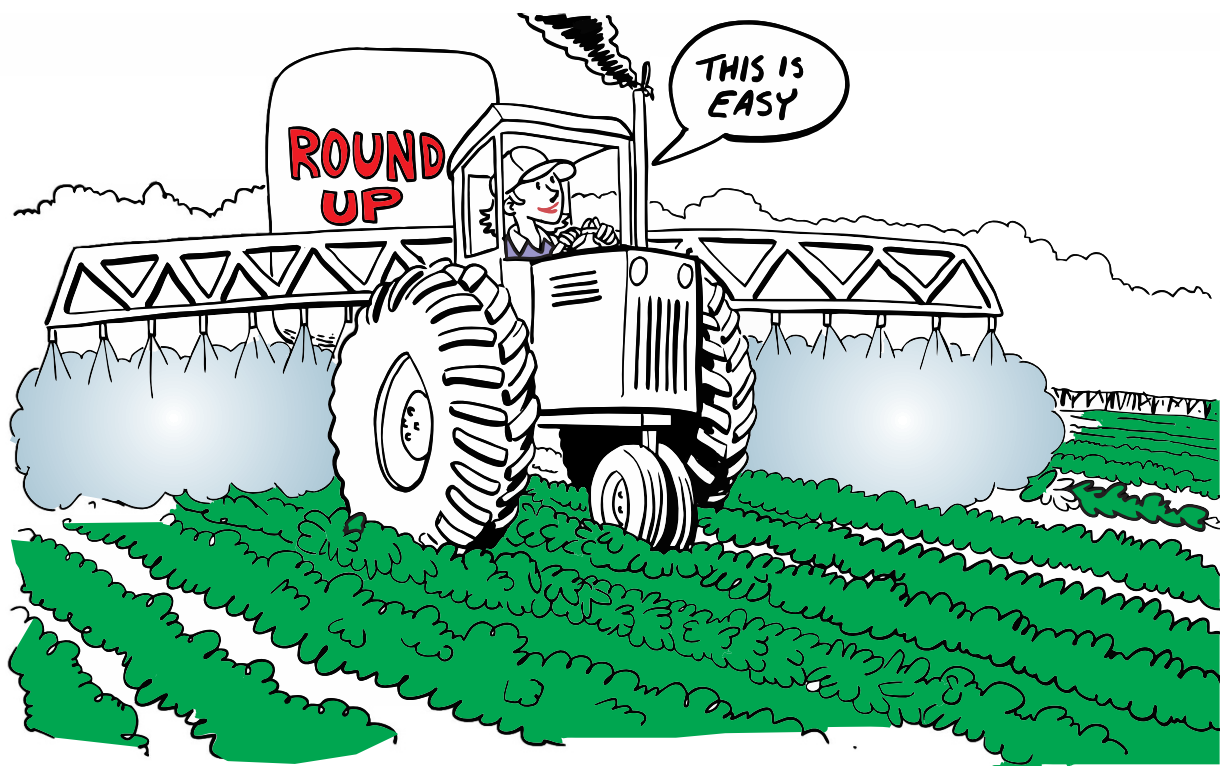


AND THAT THIS IS NECESSARY TO MEET THE DEMANDS OF OUR GROWING POPULATION THAT WILL REQUIRE ABOUT 70% MORE FOOD BY 2050⁵.



BUT CRITICS DISAGREE.

ONE PROBLEM IS THAT MOST GM VARIETIES AVAILABLE TODAY WERE NOT CREATED TO BE MORE PRODUCTIVE, OR WITHSTAND DROUGHT, OR USE NUTRIENTS MORE EFFICIENTLY, BUT WERE DESIGNED TO BE RESISTANT TO ONE PARTICULAR HERBICIDE CALLED "ROUNDUP."



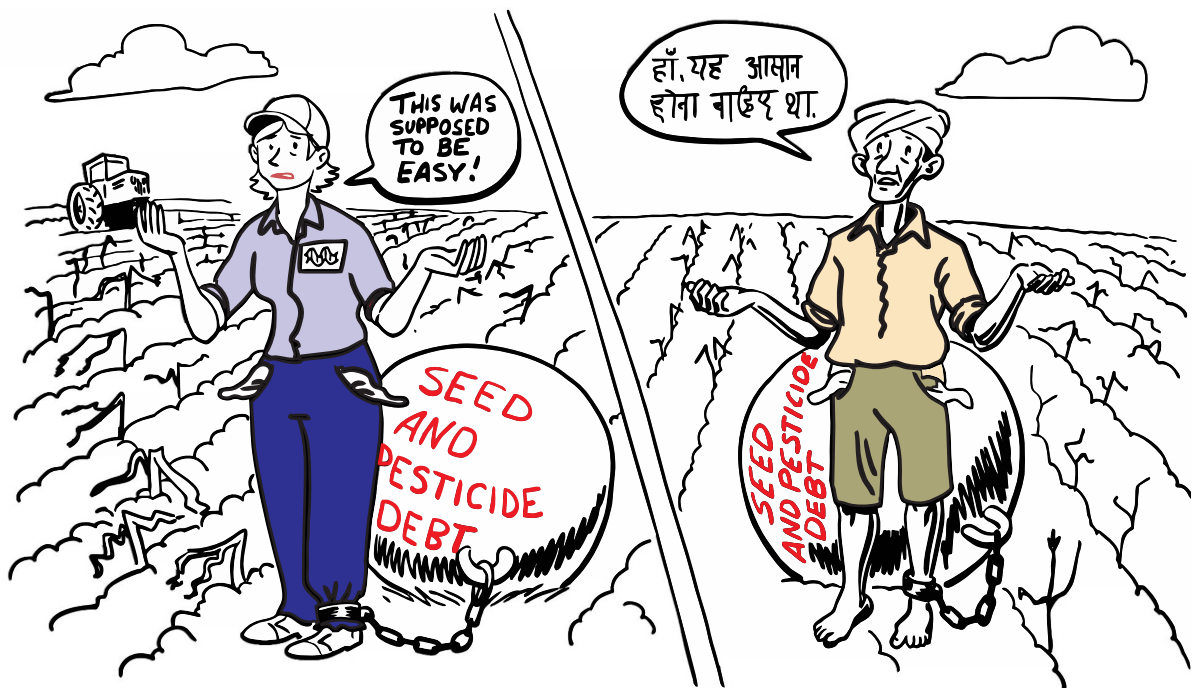
"ROUNDUP READY" CORN, COTTON AND SOY SEEDS ARE EXTREMELY POPULAR WITH FARMERS ESPECIALLY IN NORTH AMERICA BECAUSE THEY ALLOW FARMERS TO PLANT A FIELD WITH THIS "ROUNDUP READY" SEED AND THEN SPRAY THE ENTIRE FIELD WITH ROUNDUP TO KILL WEEDS.

THIS KILLS THE WEEDS BUT DOES NOT HARM THE CROP⁶.

BUT ROUNDUP HAS LED TO AT LEAST TWO PROBLEMS.

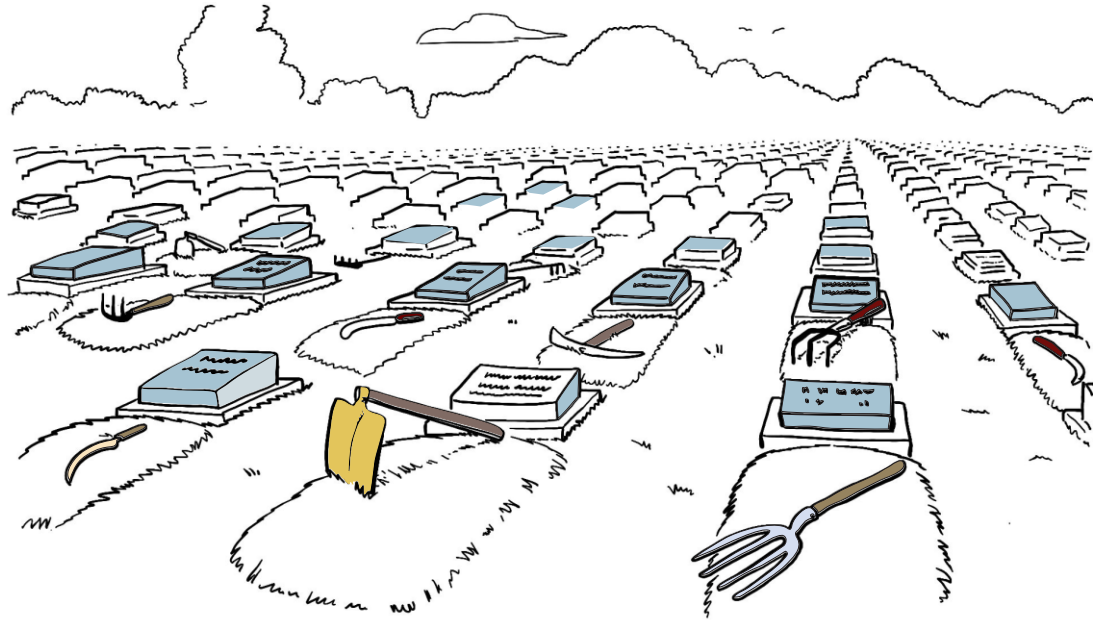


THE FIRST IS THAT THESE SEEDS AND SPRAYS COST MONEY. . .



. . . AND SO POOR FARMERS OFTEN GO INTO DEBT TO BUY INPUTS LIKE ROUNDUP AND GM SEEDS.

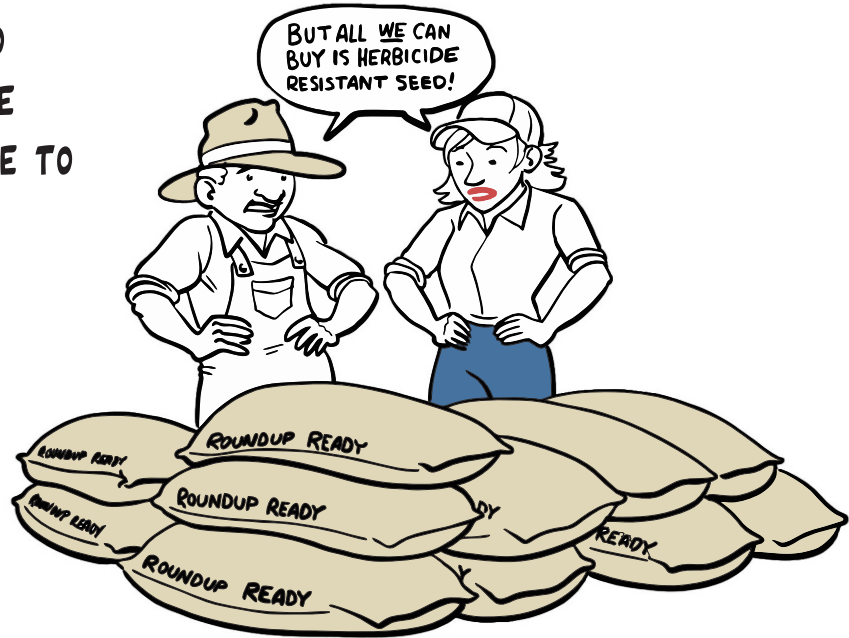
BUT IF THESE CROPS EVER FAIL, POOR FARMERS STRUGGLE TO PAY BACK THEIR LOANS. IN INDIA ALONE, WELL OVER 100,000 FARMERS HAVE COMMITTED SUICIDE IN THE LAST 10 YEARS BECAUSE OF SUCH DEBTS⁷.



SO MANY CRITICS POINT OUT THAT BIOTECHNOLOGIES LIKE ROUNDUP-READY SEEDS BENEFIT CORPORATIONS MORE THAN THEY HELP FARMERS⁸.



A SECOND PROBLEM IS THAT ROUNDUP HAS BECOME SO POPULAR THAT WEEDS ARE DEVELOPING A RESISTANCE TO THIS SPRAY⁹.



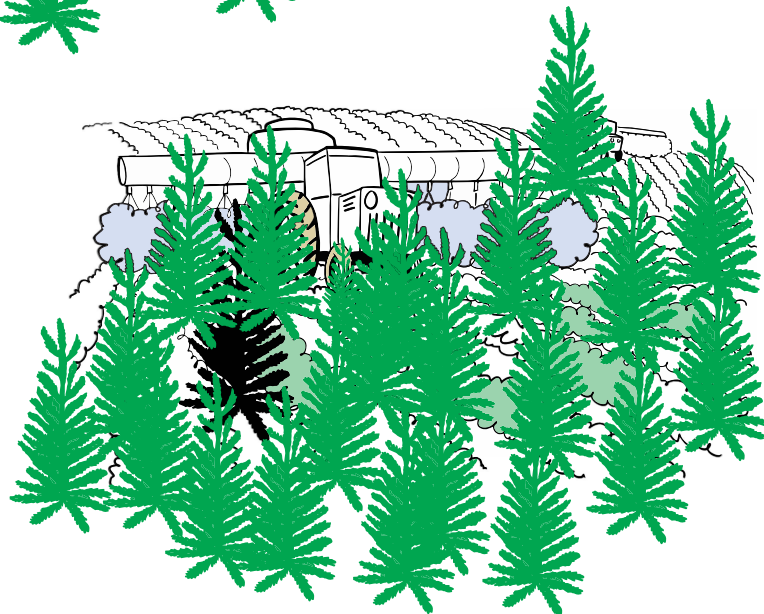
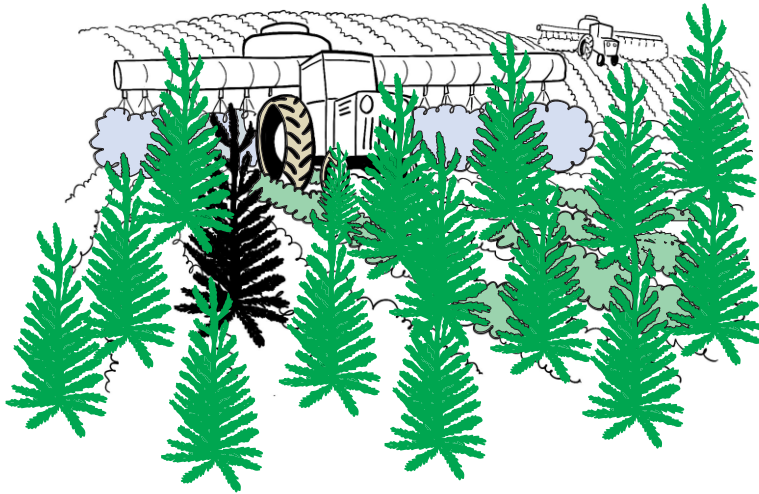
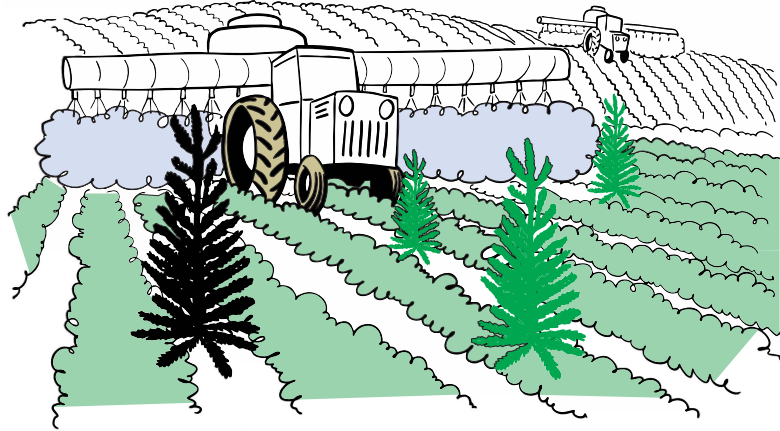
THIS IS BECAUSE IN ANY WEED POPULATION A SMALL NUMBER OF INDIVIDUAL PLANTS MAY BE RESISTANT TO THE SPRAY¹⁰.

BY USING ROUNDUP TOO OFTEN, FARMERS KILL OFF EVERYTHING BUT THOSE WEEDS THAT ARE IMMUNE.



AND IN DOING SO, SUPER WEEDS HAVE EVOLVED¹¹,

BECOMING A MAJOR PROBLEM FOR FARMERS AND ECOSYSTEMS ALIKE¹².



**BUT DO THESE
PROBLEMS MEAN WE
SHOULD REJECT
BIOTECHNOLOGY
ENTIRELY?**

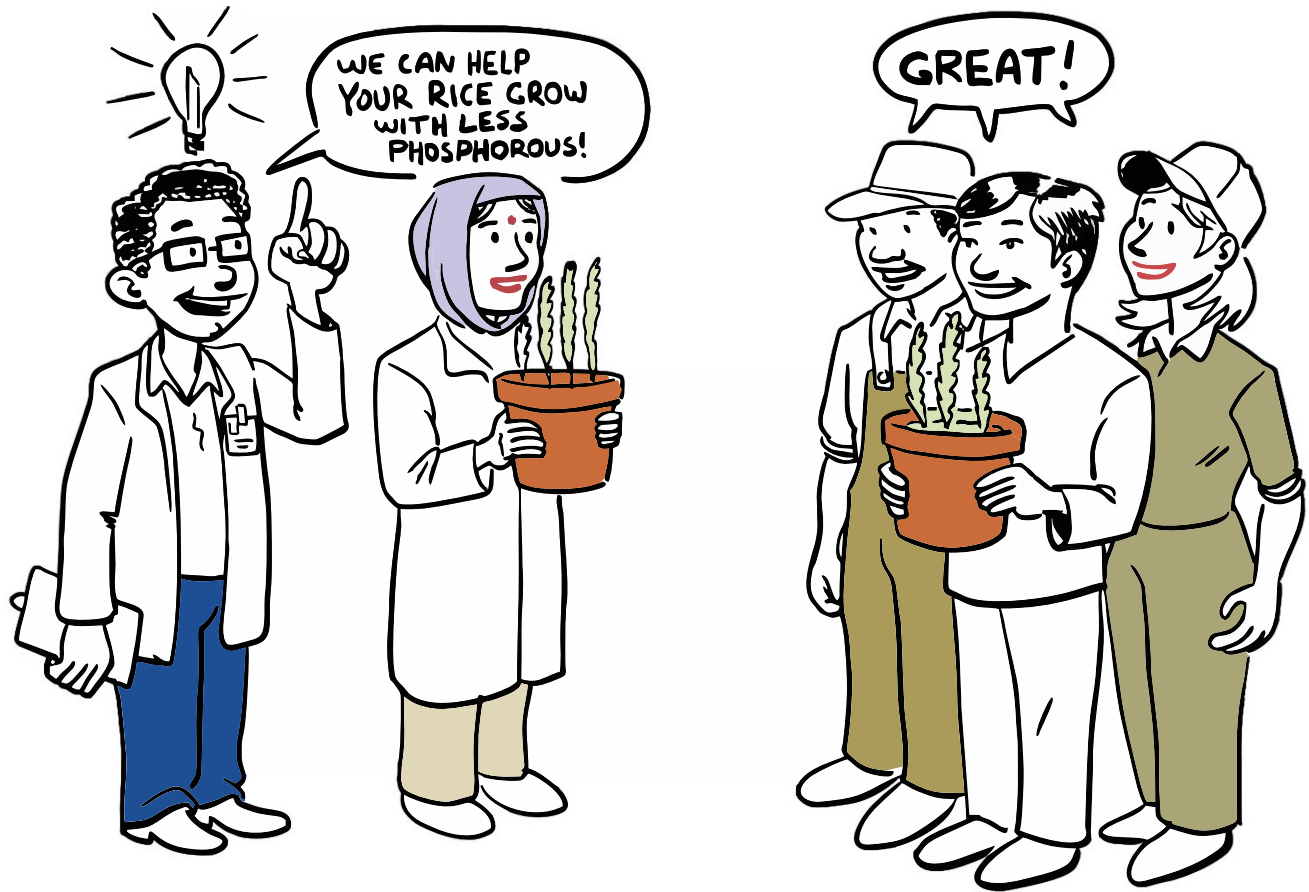


I DON'T THINK SO.



**BUT I DO THINK THAT WE SHOULD ALWAYS INVESTIGATE WHETHER LOW-TECH
SOLUTIONS EXIST TO PROBLEMS BEFORE WE START THINKING ABOUT SUCH HIGH-
TECH STRATEGIES AS MOVING GENES BETWEEN SPECIES.**

FOR INSTANCE, IN LARGE PARTS OF THE DEVELOPING WORLD A LACK OF PHOSPHORUS IN THE SOIL LIMITS YIELDS¹³. BUT IN INDIA A TRADITIONAL VARIETY OF RICE CALLED KASALATH IS ABLE TO GROW WITHOUT MUCH PHOSPHORUS.

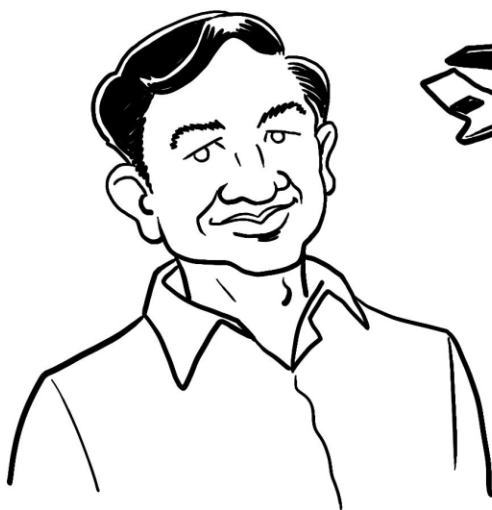


IN 2012, SCIENTISTS FIGURED OUT HOW KASALATH'S AMAZING ABILITY WORKS¹⁵ AND ARE NOW USING A SCIENTIFIC METHOD CALLED "MARKER ASSISTED PLANT BREEDING" TO MOVE THE GENE RESPONSIBLE FOR THIS TRAIT INTO OTHER RICE VARIETIES¹⁶.

THIS ILLUSTRATES THE POTENTIAL FOR BIOTECHNOLOGIES THAT AVOID MANY OF THE PROBLEMS ASSOCIATED WITH GMOS.



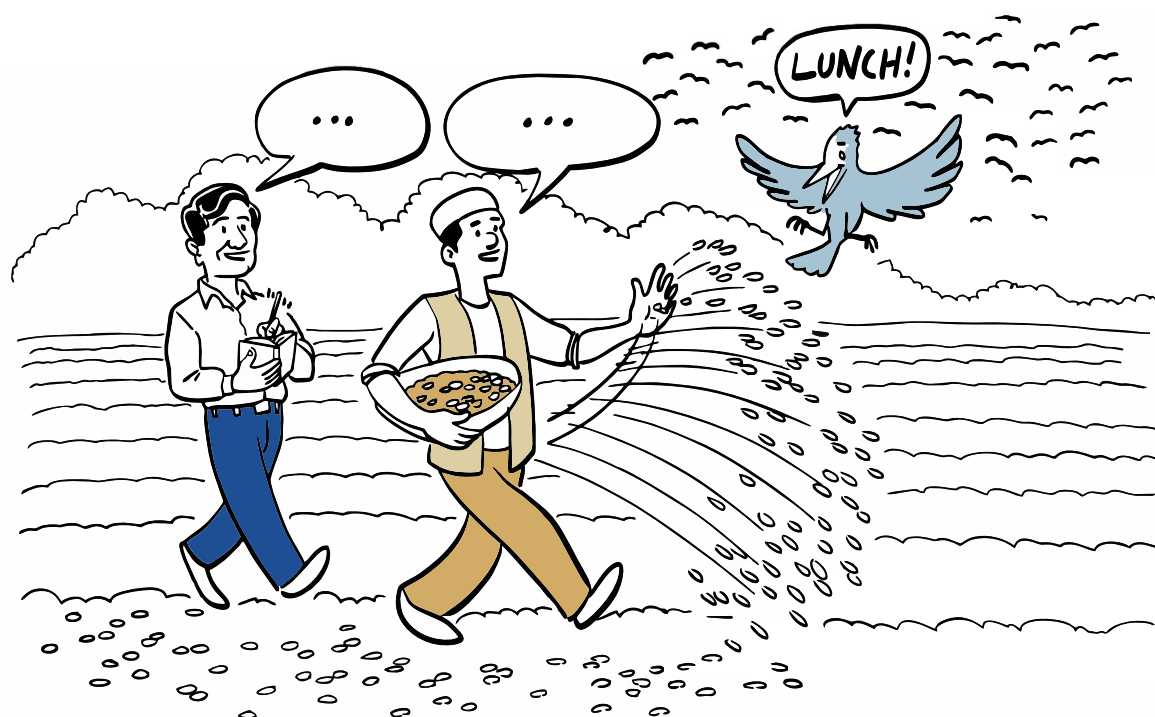
**BUT THERE ARE EVEN
SIMPLER STORIES ABOUT HOW
SCIENCE AND TECHNOLOGY CAN
PLAY A MAJOR ROLE IN FEEDING
THE FUTURE.**



Manish
Raizada

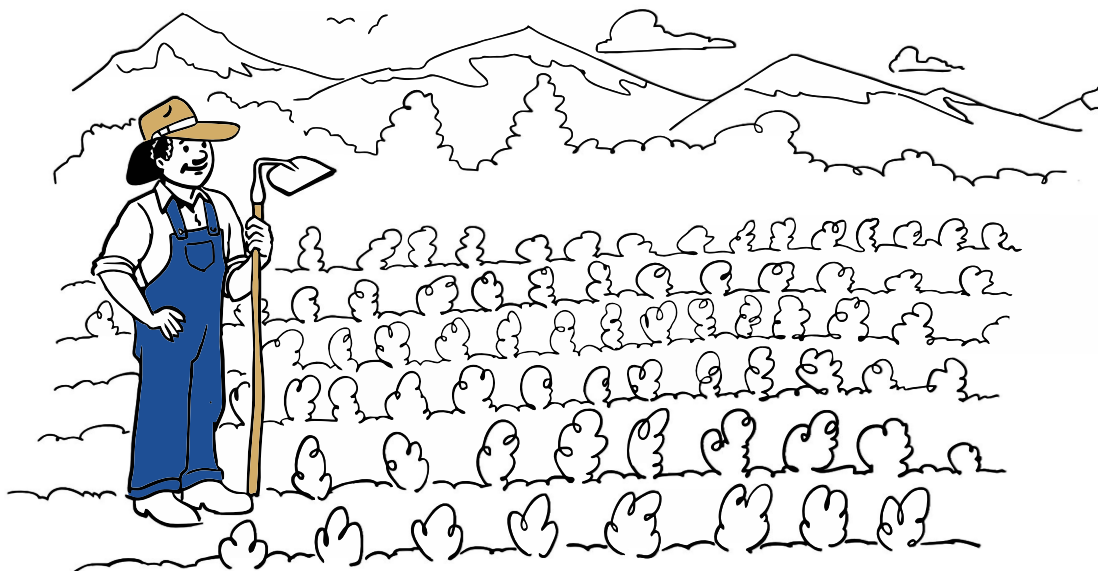
**TAKE THE CASE OF THE GENETICIST
MANISH RAIZADA WHO WORKS AT THE
UNIVERSITY OF GUELPH AND HAS SPENT PART
OF HIS CAREER USING GM TECHNIQUES TO
UNDERSTAND HOW PLANTS FUNCTION.**

UNLIKE A LOT OF PLANT GENETICISTS, INSTEAD OF STARTING IN THE LAB, MANISH BEGINS HIS RESEARCH BY TALKING TO FARMERS IN THE DEVELOPING WORLD TO IDENTIFY WHAT THEY ACTUALLY NEED.



WHILE WORKING WITH FARMERS IN NEPAL WITH A LOCAL ORGANIZATION CALLED LI-BIRD, HIS TEAM FOUND THAT FARMERS TRADITIONALLY PLANT GRAIN BY SCATTERING HANDFULS OF SEEDS INTO THE DIRT¹⁷.

BUT BY SIMPLY PLANTING SEEDS IN ORDERLY ROWS, MANISH'S COLLABORATORS SHOWED FARMERS THEY COULD INCREASE YIELDS BY 25-40%¹⁸.



THIS IS BECAUSE EVENLY SPACED SEEDS HAVE EQUAL ACCESS TO SOIL NUTRIENTS, MOISTURE AND SUN LIGHT.

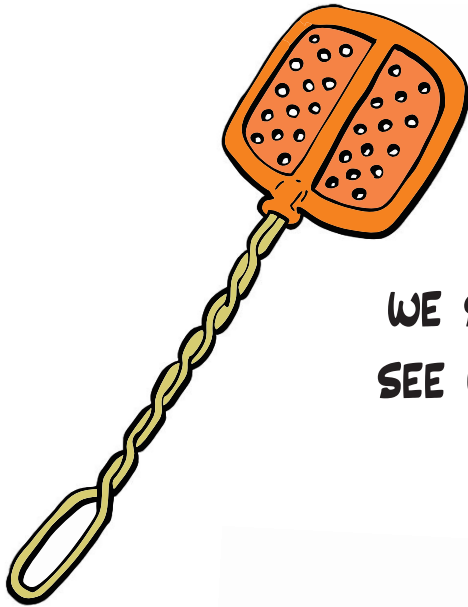
THIS TEAM DEVELOPED AN ELEGANTLY SIMPLE TOOL KIT TO MAKE IT EASY TO PLANT IN ROWS:

TWO STICKS AND A STRING TO MARK LINES IN THE GROUND, AND A HOLLOWED OUT STICK DROPS ONE SEED AT A TIME INTO THE PREPARED EARTH.

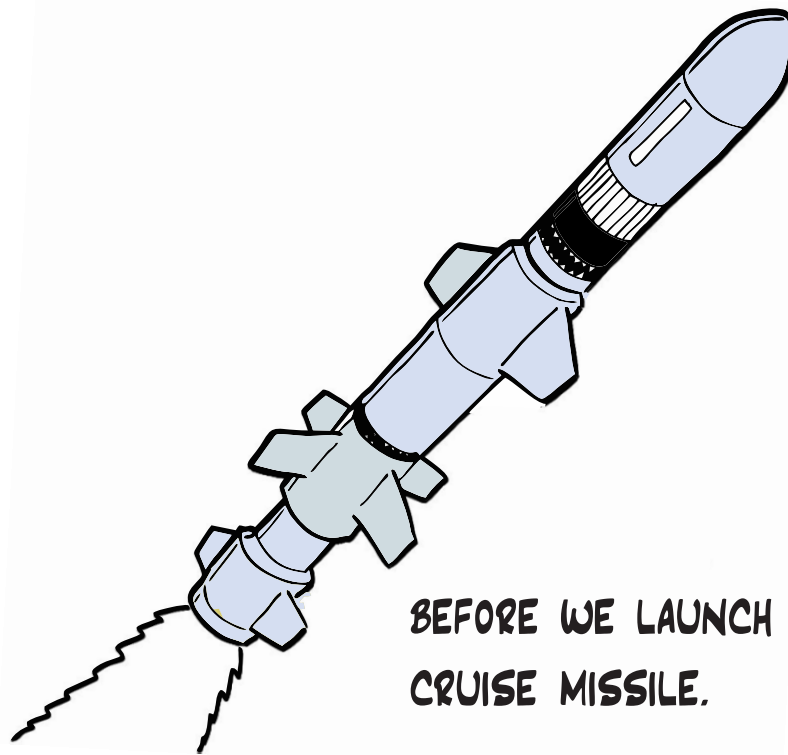


**IT'S THE PERFECT MARRIAGE OF SCIENCE AND
LOCALLY APPROPRIATE TECHNOLOGY¹⁹!**

**THE MORAL OF THIS STORY IS THAT OF THE
FLY SWATTER VERSUS THE CRUISE MISSILE –**



**WE SHOULD ALWAYS LOOK TO
SEE WHAT FLY SWATTERS ARE
AT HAND**



**BEFORE WE LAUNCH A
CRUISE MISSILE.**

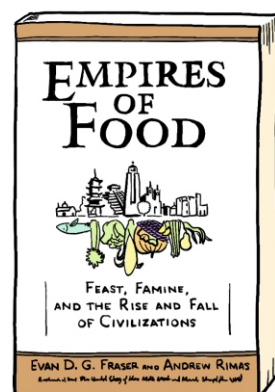
BUT THAT'S ALL FOR NOW. IF YOU ARE INTERESTED IN LEARNING MORE, YOU CAN CHECK OUT MY RECENT BOOK EMPIRES OF FOOD.

ALSO, YOU CAN FIND ME ON YOUTUBE, FACEBOOK AND TWITTER WHERE I REGULARLY POST ABOUT ISSUES RELATING TO GLOBAL FOOD SECURITY.

THE WEBSITE WWW.FEEDINGNINEBILLION.COM HOSTS ANNOTATED SCRIPTS FOR ALL THE VIDEOS ALONG WITH REFERENCES AND A BLOG.

I HOPE TO SEE YOU AGAIN, BUT UNTIL THEN, THANKS FOR WATCHING!

FeedingNineBillion.com



ENDNOTES:

¹For some background information on genetically engineered drought resistance potatoes see: [YEO ET](#), KWON HB, LEE JT, RYU JC, BYU MO. 2000. Genetic engineering of drought resistant potato plants by introduction of the trehalose-6-phosphate synthase (TPS1) gene from *Saccharomyces cerevisiae*. Europe Pubmed Central 10(3), 263-68:

<http://europepmc.org/abstract/MED/10901163/reload=0;jsessionid=dNMQIA6xug8nMTajXiXR.42>

²Here is a nice editorial that reviews some of these topics: SIEDOW, JAMES . 2001. Feeding Ten Billion. Three Views. American Society of Plant Physiologists, 126(1), 20-22:

<http://www.plantphysiology.org/content/126/1/20.full>

³Pavone offers a discussion of how framing environmental and social issues as 'problems' can encourage a search for technological solutions. See: PAVONE, V., GOVEN, J., & GUARINO, R. 2011. From risk assessment to in-context trajectory evaluation - GMOs and their social implications. Environmental Sciences Europe, 23(1), 3. doi:10.1186/2190-4715-23-3

⁴When discussing GM crops, it is important to have a basic understanding of the science behind the process. The following publication by the Monsanto Company explains some of the key terms used in the biotechnology industry, and provides some examples of GM seed varieties that successfully increased yields. "Do GM Crops Increase Yields?" Monsanto. Monsanto Company, 26:

<http://www.monsanto.com/newsviews/Pages/do-gm-crops-increase-yield.aspx>

⁵Following a 2009 conference, the FAO released this brief summary of the future food-production challenges the world faces towards the year 2050. "Global Agriculture Towards 2050." High Level Expert Forum-How to Feed the World 2050. Proc. of High Level Expert Forum-How to Feed the World 2050, Rome. FAO: http://www.fao.org/fileadmin/templates/wsfs/docs/Issues_papers/HLEF2050_Global_Agriculture.pdf

⁶While Roundup Ready crops are the most common type of GMO in our fields there are other similar crops such as BT cotton that produces its own insecticide. The following New York Times article provides some background on this topic:

http://www.nytimes.com/2010/05/04/business/energy-environment/04weed.html?pagewanted=all&_r=0

⁷This issue has been in the news a lot recently and the following article summarizes this point.

Newman, Bryan. A Bitter Harvest: Farmer Suicide in India. Institute for Food and Development Policy. University of North Carolina:

<http://www.foodfirst.org/en/node/1611>

But we also need to note that some people see this as a much bigger issue than simply farmers going into debt to buy genetically modified inputs. Here is a National Post article that takes issue with this argument and points out the farmer suicides are part of a larger phenomena than just the cost of inputs:

<http://news.nationalpost.com/2013/01/26/the-myth-of-indias-gm-genocide-genetically-modified-cotton-blamed-for-wave-of-farmer-suicides/>

⁸The following academic articles provide some background on the issue of roundup and roundup ready seeds:

- (1) ANDREWS, B. 2013. Glyphosate-resistant weed worries: How we got them, what we can do. Farmers Forum. [http://www.farmersforum.com/APRIL2013/p15%20\(W\).htm](http://www.farmersforum.com/APRIL2013/p15%20(W).htm)
- (2) BENBROOK, C. M. 2012. Impacts of genetically engineered crops on pesticide use in the US--the first sixteen years. Environmental Sciences Europe, 24, 1-13. <http://www.enveurope.com/content/24/1/24>
- (3) POWLES, S. B. 2008. Evolved glyphosate-resistant weeds around the world: lessons to be learnt. Pest Management Science, 64, 360-365. http://onlinelibrary.wiley.com/store/10.1002/ps.1525/asset/1525_ft.pdf?v=1&t=hju31ojf&s=a5d3096c87481ceb8b624c2026663b65a502eb15
- (4) SHANER, D. L. 2000. The impact of glyphosate-tolerant crops on the use of other herbicides and on resistance management. Pest Management Science, 56, 320-326. [http://onlinelibrary.wiley.com/store/10.1002/\(SICI\)1526-4998\(200004\)56:4%3C320::AID-PS125%3E3.0.CO;2-B/asset/125_ft.pdf?v=1&t=hju30mq1&s=7223f765fecbc64ed9f165196b8876c4eca94880](http://onlinelibrary.wiley.com/store/10.1002/(SICI)1526-4998(200004)56:4%3C320::AID-PS125%3E3.0.CO;2-B/asset/125_ft.pdf?v=1&t=hju30mq1&s=7223f765fecbc64ed9f165196b8876c4eca94880)

⁹Monsanto, the producer of the herbicide "Roundup Ready", has provided an explanation in layman's terms of how weeds gain resistance to herbicides. "How Resistance Develops." Roundup Ready - Weed Management Solutions. Monsanto, 2013: http://www.rwms.ca/how_resistance_develops

¹⁰See footnote 9 for the full background.

¹¹This article by the BBC discusses the growing problem of glyphosate resistance, and outlines alternative herbicides currently under development. This is contrasted with the argument of teaching farmers more traditional methods of fighting weeds. McGrath, Matt. "Agent Orange Chemical in GM War on Resistant Weeds." BBC News. BBC World Service: <http://www.bbc.co.uk/news/science-environment-19585341>

¹²It is important to note that these debates are not just about Roundup and Roundup Ready seed but also about other types of GM such as a GM cotton variety called "BT cotton" that is supposed to be resistant to the cotton budworm but that budworms are developing a resistance to. Please see: <http://www.reuters.com/article/2012/10/02/us-usa-study-pesticides-idUSBRE89100X20121002>

¹³This academic journal article explains the importance of phosphorous to crops, as well as the development of crop varieties that can thrive in

low phosphorus conditions.

Gamuyao, Rico, and Et Al. "The Protein Kinase Pstol1 from Traditional Rice Confers Tolerance of Phosphorus Deficiency." *Nature* 488.7412 (2012): 535-39. *Nature: International Weekly Journal of Science*. . <http://www.nature.com/nature/journal/v488/n7412/full/nature11346.html>

¹⁴See previous footnote for background.

¹⁵For background see the following academic article: HEUER, S., GAMUYAO, R., CHIN, J. H., PARIASCA-TANAKA, J., PESARESI, P., CATAUSAN, S., DALID, C., SLAMET-LOEDIN, I., TECSON-MENDOZA, E. M. & WISSUWA, M. 2012. The protein kinase Pstol1 from traditional rice confers tolerance of phosphorus deficiency. *Nature*, 488, 535-539.
<http://www.nature.com/nature/journal/v488/n7412/full/nature11346.html>

¹⁶The following newspaper article provides an overview of this discovery and the potential it holds for boosting yields in parts of the world where rice productivity is very limited:
<http://www.thehindu.com/sci-tech/agriculture/growing-rice-in-soil-poor-in-phosphorus-possible/article3808244.ece>

¹⁷Here is a link to a presentation by Manish, slide 31 shows pictures of traditional broadcast sowing, as compared with the more effective practice of line sowing.
Raizada, Manish N. "Sustainable Agriculture Kit Progress Report." Speech. India, Coimbatore. 24 Feb. 2012. SAK Global. Web. 18:
http://www.sakglobal.org/uploads/4/2/4/8/4248579/sak_progress_report_raizada_feb23_7pm_updated.pdf

¹⁸Here is a link to a presentation by Manish. Slide 15 is where he talks about the boost farmers get in yield if they plant in rows:
http://www.sakglobal.org/uploads/4/2/4/8/4248579/candidate_sak_interventions_raizada_feb21_small.pdf

¹⁹Low level technology that requires use of local resources have greater retention with small holder farmers. See the following as another example of appropriate marriage of science and locally appropriate technology.
Erenstein, Olaf. (2003) "Smallholder conservation farming in the tropics and sub-tropics: a guide to the development and dissemination of mulching with crop residues and cover crops. *Agriculture, Ecosystems & Environment*, 100(1), 17-37.

CREDITS

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