Plant outline: **An Outline of The Mechanisms of Weed Resistance to Glyphosate**
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A. Problem: Weeds are becoming resistant to herbicides like glyphosate
- Scientists are making crops resistant to glyphosate using genetic engineering (CRISPR/Cas9)
- Once the herbicide is distributed most weeds die, but some survive and pass down their resistant genes
- In rye grass this is a result of a weak and strong resistance mechanism

B. Solution: In this scenario the weeds that become resistant to glyphosate become less fit compared to the wild-type
- This is because ryegrass possesses many factors that determine their fitness like height, seed production, etc.
- Once ryegrass becomes resistant to glyphosate, they don't grow as tall and produce less seed as well as other fitness reducing qualities
- This means that the glyphosate sensitive biotype will have fitness advantage and eventually overtake the resistant biotype. This is the reason why glyphosate resistance has historically found to be very low.

C. Regulatory Issues: This is not the case with all herbicides and weeds. Herbicides and weed resistance must be regulated to prevent "super weeds".
- During the research done by Broster and Pratley they found that all other types of herbicides created a higher resistance in weeds than glyphosate. Some being as high as 76.5%. This means that the herbicide resistant weed is more fit than the wild-type.
- These studies were done after these herbicides were already introduced for commercial use and therefore has been used in a large quantity. This lessens our chances of controlling and monitoring herbicide resistance.

D. Proposed Regulations: Always assume herbicidal resistance creates "super weeds"
- Always test herbicidal resistance thoroughly in laboratories before using said herbicide commercially
- Create a standard for what percentage of resistance is acceptable

E. References:
- Gene replacements and insertions in rice by intron targeting using CRISPR-Cas9. Jun Li, Xiangbing Meng, Yuan Zong, Kunling Chen, Huawei Zhang, Jinxing Liu, Jiayang Li, Caixia Gao Nat Plants. 2016; 2: 16139. Published online 2016 Sep 12. doi: 10.1038/nplants.2016.139
- Castle LA, Siehl DL, Gorton R, Patten PA, Chen YH, Bertain S, Cho HJ, Duck N, Wong J, Liu D, Lassner MW. Discovery and directed evolution of a glyphosate tolerance gene. Science. 2004;304:1151–1154.
- Broster, JC and Pratley, JE, A decade of monitoring herbicide resistance in *Lolium rigidum* in Australia. *Aust J Exp Agric* **46**: 1151– 1160 (2006).

- Powles, SB, Lorraine-Colwill, DF, Dellow, JJ and Preston, C, Evolved resistance to glyphosate in rigid ryegrass (*Lolium rigidum)* in Australia. *Weed Sci* **46**: 604– 607 (1998).
- Simarmata, M., & Penner, D. (2008). The Basis for Glyphosate Resistance in Rigid Ryegrass (Lolium rigidum) from California. *Weed Science, 56*(2), 181-188. Retrieved from http://www.jstor.org/stable/25148501
- Fernández-Moreno, P. T., Alcántara-de la Cruz, R., Smeda, R. J., & De Prado, R. (2017). Differential Resistance Mechanisms to Glyphosate Result in Fitness Cost for *Lolium perenne* and *L. multiflorum. Frontiers in plant science*, *8*, 1796. doi:10.3389/fpls.2017.01796