Unintended Effects of Genetic Manipulation
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GM Maize Differs from Non-GM Maize at Molecular Level In Unintended Ways, Including in Response to Drought Stress

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Researchers have detected unintended differences in protein expression and in the expression of important plant hormones between genetically modified (GM) maize and non-GM maize, and the pattern of differences varied for normal versus drought conditions. They cite their results in calling for detailed molecular analyses to be added to risk analyses of genetically engineered plants. Risk analyses, they added, should also include studies to identify and compare the particular molecular responses of GM and non-GM varieties to environmental stressors, such as drought. Such studies should also profile the way plants engineered to tolerate an herbicide respond at the molecular level when they are actually exposed to the herbicide under stressed versus normal conditions.

Currently, routine risk analyses for GM plants do not examine how such engineered plants respond under a variety of environmental conditions, note the international group of researchers, who published their results in *PLOS ONE*. Their article, "Molecular Responses of Genetically Modified Maize to Abiotic Stresses as Determined through Proteomic and Metabolomic Analyses," included authors from universities in Brazil, Norway, and South Africa, and from the GenØk Centre for Biosafety in Norway. It was published in February, 2017.

The authors report that they detected differences in the level of three important plant hormones and six proteins when comparing, under normal (non-stressed) growth conditions, a maize hybrid genetically engineered to tolerate the herbicide glyphosate and a non-GM hybrid that was otherwise a near-genetic match. They found a separate pattern of differences in molecular expressions between the two varieties — in terms of the relative abundance of particular proteins — when both varieties were tested under severe water restrictions akin to drought conditions.

They found yet another set of molecular responses for the GM plant when testing it under a combination of both severe water restrictions and applications of glyphosate. (Since the GM version is engineered to tolerate glyphosate, GM maize crops can be heavily exposed to the herbicide when farmers use it to kill nearby weeds. And droughts are of increasing concern with climate change. Hence the researchers' interest in this condition.)

A higher level of four proteins that are involved in carbohydrate and energy metabolism was found in the GM maize, under normal watering conditions, which is in line with results from earlier studies which also found that some proteins involved in carbohydrate and energy metabolism were more abundant in GM samples, versus their conventional counterparts. That suggests that "GM crops have a higher energy demand in comparison to conventional plants, which do not bear the necessity of calling upon energy sources to synthetize transgenic proteins." Two other proteins that may be related to photosynthesis were less abundant in the GM variety under normal watering conditions. Given these results, further research is needed to explore whether genetic modification has reduced the rate of photosynthesis in the

GM maize, and, if so, if that imposes "additional burden on plant development."

The researchers, considering both their drought and non-drought results, concluded: "Overall, the differences in the protein profile and metabolite levels" between the GM maize and its near-isogenic (that is, nearly genetically identical) non-GM variety "can affect many physiological processes and biochemical pathways, such as photosynthesis-related pathways. Taken together, our results demonstrate that these two hybrids may not behave similarly at the molecular level, thus precluding the assumption that they are substantially equivalent."

That's an important point, they argue, because substantial equivalence — which they define as "the close nutritional and elemental similarity between a GM crop and a non-GM" variety that is nearly genetically identical — is often claimed, in arguing that a particular GM crop is as safe and nutritious as non-GM crops.

"However, the parameters, criteria and analyses used to declare a GMO [genetically modified organism] substantially equivalent are unclear and reduced to a limited set of variables, such as the total amounts of carbohydrates, proteins and minerals," the authors add. "In addition, pesticide residues can become part of the composition of a herbicide-tolerant GM plant, and they may add toxic properties to the final plant product, either alone or by affecting plant metabolism. Nonetheless, the identification of such pesticide residues is overlooked in compositional analyses. Therefore, one of the most reliable ways to detect unintended consequences of genetic modification is through a more detailed survey of molecular components."

The researchers call for the development of databases that include profiles of genes, proteins, and plant hormones and other metabolites for important crops, tracked across a range of environmental conditions, to be used to assess crop safety. They add that, given the new kinds of GMOs now being developed, "wide use of molecular profiling should be added to the required criteria for risk assessment," before such GMOs are approved by regulatory agencies.

The full text of the paper is available at: http://journals.plos.org/plosone/article?id=10.1371/journal.pone.0173069

Sources

Benevenuto, Rafael Fonseca, Sarah Zanon Agapito-Tenfen, Vinicius Vilperte et al. (2017). "Molecular Responses of Genetically Modified Maize to Abiotic Stresses as Determined through Proteomic and Metabolomic Analyses," *PLOS ONE* 12(2): e0173069. doi:10.1371/journal.pone.0173069.