“Improved Food”: The Future of Genetic Modification in the Agricultural Industry

Victor Wall

Agriculture as an industry has changed significantly over the course of human history.  From its early days of selective breeding to the modern innovations of CRISPR and other gene editing programs, pressures from within and without the industry have shaped it.  However, with growing attention to the practice just a century old, many look towards this controversial system as an overreach of human behavior, or that of a poorly understood endeavor.  Within this project, the impacts of three particular areas of agriculture that CRISPR and other  modern genetic  modification programs  have changed will be examined. Those include the impact on plant science and crop production, the impact on livestock, both small-scale and industrial,  and the impact on food science and human health. Each of this triad is part of an interconnected web within the industry, and a generalization of the major components of modern agriculture.  By exploring this connection, it is hoped that viewers of this project will attain a more comprehensive understanding of their food and the work that goes on within the industry.

Plant science has always been an area rife for genetic research and experimentation, ranging from the first crop selections before modern science. However, at the tail end of WWII, there was a rush of innovation in the field of agriculture. In 1944, Doctor Norman E. Borlaug joined the Rockefeller Foundation, through their work on the Mexican Agricultural Program’s director. At the time, Mexican wheat crops were suffering from outbreaks of stem rot, a debilitating fungal disease that had the potential to quickly ruin an entire wheat field. The MAP began to experiment with hybridization as a solution, developing crosses of rust-resistant foreign wheat and high-yield native breeds In order to facilitate this, Borlaug pioneered a method known as ‘shuttle breeding’ in 1945, in which seeds were moved from areas with quicker growing seasons over to areas with slower growing seasons, in an effort to maximize the production season. This method was a success, and resulted in Mexico becoming a self-sufficient wheat producer by 1956 (Rockefeller). Borlaug also pioneered the usage of dwarf cultivars in the Mexican wheat industry. The dwarf-cultivars, which possessed a squatter frame then the native breeds while still retaining the same amount of grains, were further able to optimize a wheat field by allowing farmers to fit more of the breeds into their fields, ensuring a better return on space and water efficiency. This was applied with much success to Mexican and Indian wheat, and led the way in Philippine rice production, eventually leading to the latter becoming a self-sufficient importer. Through these efforts, Borlaug established a precedent for approaching  current agricultural  issues, and a method of prioritizing industrial style farming paired with constant genetic modification, laying the foundation for crop sciences as a whole. In his legacy,  crop scientists  have focused on applying genetic modifications to the  current industrial selection, as a means of refining the Borlaug process. Whereas a dwarf cultivar might have prior been bred for space and water efficiency, it can now be altered on the genetic level to ensure high yields, resistance to common pests, and even arid soil compatibility. Additionally, many commercial cultivars are now bred to be resistant to conventional pesticides and insecticides, allowing farmers to apply fields with such substances without risk of undue damage from them. This  allows for  a more versatile product, and, in turn, one that can eliminate many conventional needs in the ways of fertilizers and irrigation. However,  due to the  often free propagation of plants, legal issues have emerged as a result of cultivars on neighboring fields becoming crossbred or cross-propagated with  modified plants, resulting in hybrids of ambiguous ownership. Determining responsibility for such strains is another potential issue, as private corporations would hold the rights to the modifications made for a now feral plant. The question of whether such an ownership connects to responsibility is one that will have to be resolved in the future ahead. Some companies, such as Monsanto, have attempted to resolve this issue by suing private farmers for exclusive patent retention, a practice publicized and heard in the 2013 Bowman V. Monsanto case, which ruled that crop grown from stored company seeds would still be considered patented company product. However, the Supreme Court stated that such a ruling was highly situational, and only pertained to the matter of stored seeds. Furthermore,  unregulated propagation could result in cultivars leaving beyond  the confines of their farms, resulting  in the creation of feral strains.

 In many ways, livestock’s history with genetic modification has been similar to that of its floral counterpart.  Starting with selective breeding, the industry has endeavored to ensure improvement with their stock, with the process becoming more refined as time went on.   Artificial insemination (AI) revolutionized the process, allowing for the transferal of genetic material beyond that of physically present breeding partners, even enabling a donor’s genetic material to be transmitted after their death.  This, in turn, led to further surrogate research, and eventually allowed for the establishment of genetic industry standards, enabling members of the industry to import the material to their own farms  as requested and apply as necessary. With CRISPR and other gene editing methods, this methodology has had an additional component introduced to it:  transgenics. As there is no longer a material limitation with that of  AI,  genetic material can be introduced from a number of myriad sources, cultivated from recessive lines, or even ‘imported’ from non-native sources, such as introducing warthog genes into that of  domestic hogs (Yang, Huanguing, and Wu, 2018).  This substitution resulted in a reduction of fat in the transgenic mods, and led to an increase in muscle mass for the hogs in question. Furthermore, since the adjustments were made on the genetic level, the modifications can be passed down to the next generation of hogs, ensuring that continual therapy is not necessary for the next generation of commercial pigs. Additional work is also being done to reduce the risk of cardiovascular diseases, birth defects, and risk of zoonotic disease transmission.

 Though this has been most successfully applied to mammals such as cattle, sheep, and pigs, the poultry industry has also had success in using gene editing  as a scaffolding model. By applying   a program such as CRISPR to a ‘base’ bird,  agricultural scientists can then  attempt to ‘reverse engineer’ future lines of birds,  selectively breeding and cultivating genetic lineages that would match the base as ideally reflected.  However, as with modified plants,  modified animals also possess a potential for  outside contamination. With the risks of invasive species already significant, the addition of escaped modified animals would escalate such matters. Additionally,  it is possible that the  escapees would be able to breed with preexisting feral or wild populations, thereby disseminating those modifications throughout them. The South Carolina feral hog population, initially propagated by escaped hogs and their descendants, received a sharp boost in survivability and resilience in the 1990s, when several Russian boars imported by big game hunters broke free from their enclosures, and disseminated amongst the wild swine populace. This resulted in the already burgeoned feral hogs becoming a non-recoverable species, with the South Carolina state government shifting their efforts towards containment procedures, writing off any methods of population reduction as a lost cause. It is possible that something similar could occur in the future for feral modified hogs.

Human health has been changed significantly by the advent of genetically engineered   foodstuffs.  As the majority of modified  crops are utilized as feed for livestock, the resultant increase in nutrition from specifically maintained cultivars makes its way  into that of the  eventual human consumers. This, in turn, means that most people are affected by the  interactions between the two.   There are a number of particular advantages to such a system. With an increase in nutrition from meals, human health will increase, thereby allowing for decreased expenditures on vitamin supplements, medical care, and other accessory items related to common health conditions. Additionally, the usage of genetically modified foodstuffs could serve to aid those with preexisting health conditions, such as those that are immunocompromised, by providing a safer and more robust meal option to them. Inversely, however, modified meals could also pose a risk should adverse effects be caused by the modifications in question. Furthermore, though all the components of a modified meal may be acceptable when separated, combining them may result in unexpected occurrences, that could be hazardous to human health.  This, in turn, would lead to more ownership disputes.

Agriculture has been altered extensively due to the introduction of genetically modified products, and with its pedestrian use, it is important to consider how and why they are applied. As the demand for foodstuffs increases, continual usage will likely  rise, allowing for more development in the field alongside that of other, alternative methods.  Due to this, it is beneficial to look towards the current innovations being made within  the industry, in an effort to  predict  what  the future holds for agricultural science.

Works cited:

Sciences, National Academies of, et al. “Human Health Effects of Genetically Engineered Crops.” *Genetically Engineered Crops: Experiences and Prospects.*, U.S. National Library of Medicine, 17 May 2016, www.ncbi.nlm.nih.gov/books/NBK424534/.

ServickAug, Kelly, et al. “CRISPR Slices Virus Genes out of Pigs, but Will It Make Organ Transplants to Humans Safer?” *Science*, 8 Dec. 2017, www.sciencemag.org/news/2017/08/crispr-slices-virus-genes-out-pigs-will-it-make-organ-transplants-humans-safer.

“The Rockefeller Foundation.” *Norman E. Borlaug - Biographical - The Rockefeller Foundation: A Digital History*, rockfound.rockarch.org/biographical/-/asset\_publisher/6ygcKECNI1nb/content/norman-e-borlaug.

Yang, Huaqiang, and Zhenfang Wu. “Genome Editing of Pigs for Agriculture and Biomedicine.” *Frontiers in Genetics*, Frontiers Media S.A., 4 Sept. 2018, [www.ncbi.nlm.nih.gov/pmc/articles/PMC6131568/](http://www.ncbi.nlm.nih.gov/pmc/articles/PMC6131568/).