

## Refuge Plots II

Arthur T. Johnson

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When we finally wrest the ultimate secrets of biological control, will we know how to use them wisely? There is evidence given in *Lancaster Farming* that we will not. In the November 10, 2012 issue, an article appeared that reported that the agricultural uses of herbicides and insecticides were on the increase after a short period of decline. What this means is that the advantages given to growers of genetically-modified (GMO) crops will be short-lived at best.

Remember that Roundup-Ready corn, soybeans, cotton, alfalfa, and other crops contained a gene that made these crops resistant to the popular and relatively less dangerous herbicide Glyphosate (commercially sold as Roundup). Spraying Roundup-Ready crops with Glyphosate would kill the unprotected weeds but leave the crop unharmed. Competition from weeds for water, nutrients, and light was eliminated, and crop yields increased greatly, with little increase in cost.

Bt (*Bacillus thuringiensis*) corn contains an inserted gene that kills the larvae of corn earworm, the most destructive pest of corn. Planting Bt corn eliminates the need for most insecticidal sprays, increasing yields while decreasing costs.

Scientists at Monsanto, the developer of Roundup-Ready crops knew that there was the possibility that something could go awry. Nature, after all, is nothing if not resilient. So, they recommended that 10% of crop area be planted with non-GMO varieties. This was later amended to be 15%. These areas were known as Refuge Plots.

The idea behind Refuge Plots was a good one. They were meant to allow the breeding and survival of weeds or insects not harmed by the genes inserted into the GMO crops. These pests would have no evolutionary pressure to become resistant to the inserted genes. Those weeds and insects that inevitably developed resistance to Glyphosate or Bt toxin would cross-breed with the nonresistant pests, and thus delay, or even eliminate resistances from passing to the next generation.

But guess what? Glyphosate-resistant weeds have become a real problem in Midwestern corn and soybean fields. So, now growers must not only spray Glyphosate, but they also must spray with more dangerous herbicides, such as 2,4D. As a result, the agricultural use of herbicides has gone up rather than down.

Left in the hands of scientists, these problems may have been avoided, but when practiced by a large segment of the populace, they have developed robustly.

This is a classic example of the cheater's dilemma. If there is an advantage to be gained by cheating, then the cheater wins the game. But, if everybody cheats, then everybody loses. There was an economic advantage to ignore the refuge plot and plant only the GMO crop. So,

apparently, growers asked themselves why they had to relinquish the advantages of the GMO crops on 15% of their land and be satisfied with 85% of the profit they could have. Seeing no particular advantage for themselves to follow the recommendations, enough of them cheated. Now everyone pays the price.

If we think that it is only ignorant farmers who cause these problems, then we need only look to medical professionals to see that even among the learned the same tendencies prevail. Medicine has overused one powerful antibiotic after another, or, also, one powerful antimalarial drug after another. The refuge plots for these medicines were the instances that they were not required, allowing some medical conditions to heal without them. Instead, the wonder medicines were used nearly every time, and resistant organisms developed. The result of this is that pharmaceutical companies are scrambling to find new means to control or cure diseases.

This brings me to synthetic biology, using what we know about functional genomics to produce new living organisms to serve our needs. Scientists at NIH have for a while now issued a set of guidelines for the careful introduction of transgenic organisms into the environment. In general, these guidelines have worked well; environmental disasters of this kind have not happened.

But what happens when the development of new synthetic organisms becomes commonplace? They will probably have advantages, mostly economic, for their uses. Who will be able to keep the cheaters in check? How can we avoid the seemingly inevitable environmental disaster that could ensue when these new organisms escape confinement? History shows that we won't be able to avoid the consequences.

We are rapidly approaching the time when we will know enough about genomes, epigenetics, gene regulatory mechanisms, cellular inclusions, and proteomes that we will be able to manipulate living organisms to do almost anything we dream possible. Synthetic organisms could be everywhere and do many wondrous things. Perhaps I am overly pessimistic about these things, but I can see that it will take a whole lot of reasoning and wise agreement in order to avoid environmental disaster. After all, humanity has so far avoided blowing up the world with atomic bombs, but, in that case, everybody didn't have one.