

In spring of 2014 the Dean of OSU's College of Agricultural Sciences charged a faculty committee to review and summarize key considerations related to genetically engineered (GE) organisms. The committee chose five topics that engaged faculty expertise and that reflected public interest regarding GE organisms in agriculture.

Committee members drafted these white papers as a service to the public for the purpose of providing information from several scientific perspectives. These papers have been reviewed by all committee members and are intended to help inform public conversations about genetically engineered organisms in agriculture.

IMPLICATIONS OF GENE FLOW AND NATURAL SELECTION IN GENETICALLY ENGINEERED CROPS

OSU-CAS Committee
September 30, 2014

WHAT IS GENE FLOW?

Gene flow is the change in gene frequency in a population due to movement of genetic material, individuals, or groups of individuals from one place to another. Gene flow was one of the first issues raised about the introduction the genetically engineered (GE) crops.

In plant crops, gene flow occurs via pollen and seed movement. Gene flow happens to some degree in all plant crops, whether genetically engineered or bred traditionally; it even happens in predominantly self-pollinated crops, such as wheat and rice. Gene flow is not generally considered to be an issue in crops using traditional breeding, unless the crops are being grown for seed and genetic purity is necessary.

Gene flow via pollen requires genetic compatibility between species; the species must occur in the same area and their flowering periods must overlap. It is difficult to predict how far a pollen grain will move. Most pollen is viable for only a matter of hours. Gene flow via pollen cannot be prevented with the technology that is now being used to breed crops, whether through biotechnology or traditional breeding.

Gene flow via seed dispersal happens through natural dispersal, such as water and wind ,and through operations in the agricultural production system, such as planting, harvest, and transport. Gene flow via seed cannot be prevented and mitigation is difficult.

Adventitious presence is the unintended presence of genetically engineered material in an agricultural commodity and can occur through pollen or seed movement. Adventitious presence is also referred to as *low level presence*.

WHY ARE PEOPLE CONCERNED ABOUT GENE FLOW?

Gene flow from GE crops to organic and conventional crops is a big agricultural concern, primarily market driven and based on consumer preference. USDA organic regulations do not permit the planting of GE crops but do not preclude the sale of a crop as organic if there was pollen flow from a neighboring GE crop. However, organic markets may refuse to accept the product if, during testing, it is found to contain a GE trait. There are conventional growers who are producing guaranteed non-GE crops who share the same concerns about *adventitious presence* that would prevent the sale of their products.

Non-agricultural issues of gene flow are related to the consequences of genes flowing from GE crops to native or naturalized species. For example, there are concerns that gene flow would reduce biodiversity, or that increased weediness of non-native species would negatively impact native or endangered species. In the U.S., GE cotton and canola are the only commercialized genetically engineered crops that have related species that occur outside of agricultural cultivation.

Creeping bentgrass has several sexually compatible native or naturalized species. Hybrids between GE creeping bentgrass and redtop and rabbitfoot grass were identified outside of cultivated fields of GE creeping bentgrass, grown for seed in Oregon but never approved for commercial sale. Gene flow between GE alfalfa and feral populations is likely if the plants are within the range of pollinator movement. Other GE crops under development, for example wheat and rice, have compatible species that occur in the areas of production. Depending on the trait, gene flow might expand the area where these species occur. For example, a gene that imparts disease resistance, or drought or salt tolerance, might lead to a weed that would survive in a new environment and could therefore negatively impact the species in that environment.

HOW CAN GENE FLOW BE REDUCED?

Gene flow via pollen can be reduced using separation in time and space so that compatible species are not flowering at the same time or are located far apart so the opportunity for cross pollination is reduced. Biological barriers such as male sterility or, in an outcrossing species, placing the transgene only in the maternal parent, can reduce gene flow via pollen. Mapping systems have been used to address isolation distances for production of some crops. Field locations are marked and growers can determine the proximity of a compatible crop.

Gene flow via seed can be reduced by monitoring each operation, cleaning equipment such as planters and combines, producing crops where volunteers are easily identified and controlled, or producing crops where there is a reduced chance of seed mixing to occur.

It is important to recognize that gene flow *will* occur. The only way that coexistence between GE and non-GE crops can be achieved is to set tolerances for adventitious presence, because it is impossible to guarantee zero gene flow.

GE CROPS AND NATURAL SELECTION OF RESISTANT BIOTYPES

The widespread planting of GE crops resistant to glyphosate and Bt (*Bacillus thuringiensis*) has led to the evolution of resistant weeds and insects because of increased selection pressure.

The increased use of glyphosate on so many acres quickly selected resistant weeds. In particular, two glyphosate-resistant pigweed species, Palmer and waterhemp, are widespread in fields where GE glyphosate-resistant crops were produced. The resistant weeds have resulted in changes in production systems, increased cost of weed control, and in some cases, growers reverting to tillage and hand weeding to manage the weeds. Glyphosate-resistant weeds are not always associated with the GE crops but have evolved under conventional production, especially in orchards where glyphosate has been used for many years and was often applied multiple times during a given year. However, the number of acres infested with glyphosate-resistant weeds is much greater in association with glyphosate-resistant crops.

Genetically engineered Bt-resistant corn contains a gene or genes from a soil bacterium that allows it to produce a toxin that kills specific insect pests. Initially, in order to delay resistance, the U.S. Environmental Protection Agency required that growers of Bt-resistant corn plant 20% of their corn acres to non-Bt-resistant corn. This area was referred to as a 'refuge.' The refuge was planted to maintain susceptible individuals that could mate with resistant individuals that might be selected within the Bt corn fields and thus reduce the number of resistant offspring. Western corn rootworm with resistance to one of the Bt toxins used in GE corn was identified in 2009 (Gassman et al. 2011) and subsequently western corn rootworm with cross-resistance to multiple Bt toxins were identified (Gassman et al. 2014). The delay in evolution of Bt resistance as compared to glyphosate resistance was likely due to the requirement for the refuge. However, EPA has relaxed the acreage requirement for the refuge, which could lead to the evolution of more resistant populations .

Insects with resistance to Bt toxins have the potential to limit the usefulness of spraying Bt on non-GE crops including organic crops where Bt is one of the few approved insecticides. Although not common, other insect species resistant to Bt toxins evolved which were not associated with the use of GE crops.

REFERENCES (PENDING)
