Case Study One – Open farming of genetically modified (GM) corn. Is it ethical?

XX

Insect Biologist specialized in biodiversity

A group of farmers in Italy had their fields seized by the local authorities. The fields were being used to farm GM corn which is forbidden by local law. Famers have claimed that MON810 (commercial name of Bt-corn) is well tested and safe for open field application. As a team we must look at this complex case from different perspectives like the effects of GM corn on plant biodiversity, the corn market and the environmental ethics concerned. We must make a recommendation as to whether the farmers should be refunded for the damage done, as the local court of justice does not have the resources to make the decision. Also, a recommendation needs to be made to change the current legal framework.

Our team of consultants includes a scientific expert on the Genetically Modified Organisms (GMOs) panel, an environmental ethicist, a plant scientist, a professor of agronomy, a corn market expert and an insect biologist. The scientific expert on the GMOs panel, XX, will look at current legislation produced by the European Union (EU) surrounding GM crops and the differences between it and neighbouring countries legislation. XX, the environmental ethicist, will be assessing any environmental impacts associated with growing Bt resistant corn in open fields. XX, the plant scientist from an industrial consulting firm will examine how the Bt corn will affect the agricultural industry. The Professor of agronomy, XX will explain the science behind plant genetics and physiology and will look specifically at the science behind the different aspects of Bt corn. The expert of the corn market, XX, will assess the potential profit/loss regarding GM corn. The potential loss due to crop failure will also be looked at.

As the insect biologist specialized in biodiversity I will be interested in the effect Bt corn has on target and non-target insects. I will look at how the target insect is exposed to Bt and how Bt kills the insect. I will investigate whether Bt corn or conventional insecticides are more harmful to non-target species. I will examine the overall effect on biodiversity and the potential problems posed by the use of Bt corn.

Bacillus Thuringiensis

Bt is a common, soil-dwelling bacterium called Bacillus Thuringiensis. It is mainly found in soils around the world and also on the leaves of plants and in stored grain. Some strains of Bt kill insects with toxins called delta endotoxins. Delta endotoxins are highly effective at controlling Lepidoptera larvae and caterpillars. It is during the larval stage when most of the damage by the European corn borer occurs (Bessin, 2004). Delta endotoxins are stomach poisons that must be eaten by the insect in order to be effective. Within minutes of the toxin being ingested the protein binds to the gut wall and the insect stops feeding. After a few hours the gut wall breaks down and normal gut bacteria invade the body cavity. The insect dies of septicaemia as bacteria multiply in the blood. This means that damage to the plant stops soon after the insect is exposed to the toxin (Velkov et al. 2005). Other Bt toxins are vegetative insecticidal proteins (VIPs). There are approximately 600 different strains of Bt that produce different forms of delta toxins. Many are toxic to caterpillars like the European corn borer while others are toxic to beetles like corn rootworm or flies like mosquitoes. Among Lepidoptera larvae, species differ in sensitivity to the protein (Romeis et al. 2006).

Insecticides

Bt insecticides consisting of dormant Bt and delta endotoxins have been available commercially and used in agriculture for over 30 years. They are used mainly for the control of caterpillar pests of various crops as well as mosquito and black fly larvae. Delta endotoxins and VIPs are more selective and therefore safer for humans and non-target organisms than most conventional insecticides because they attack sites that are found only in a few groups of insects. Using Bt corn as opposed to using the Bt toxin as an insecticide has many advantages. Bt toxins sprayed on plants break down quickly when exposed to UV light wheras, Bt toxins produced in the plant are protected from UV light. The corn borer is a difficult pest to control with contact insecticides. Contact insecticides can wash off with rainfall. Often large amounts of insecticides are used due to the fact that they need to be reapplied. Yet once larvae have burrowed into the corn stalks it is impossible to kill by conventional spraying techniques (Rice, 1998). Bt corn eliminates this use of large amounts of insecticides.

BT Corn

The production of delta endotoxins and VIPs is controlled by a single gene in the bacteria. There are four Bt delta endotoxin genes cry1Ab, cry1Ac, cry2Ab and cry9C used commercially in corn (Velkov et al.2005). A modified version of the gene can be placed into corn plants via insertion of a plasmid. The plasmid contains a promoter and an intron. The plasmid contains a cauliflower mosaic virus 35S promoter and an hsp maize intron sequence that promotes the expression of CrylAb gene (Romeis et al. 2005). This gene codes for the production of delta endotoxins. Corn plants containing this gene can produce delta endotoxin (Cry protein) and therefore can be poisonous to insects that are susceptible to that form of the protein. Many different Bt corn hybrids are available. Previous to the use of the cauliflower mosaic virus promoter an antibiotic resistant promoter was used. This caused concern amongst the public. This type of promoter is no longer used in Bt corn.

Monarch Butterfly

There is controversy between Bt corn and the Monarch butterfly as people believe that the pollen produced by Bt corn could kill monarch caterpillars. The caterpillar stage of the monarch feeds on milkweed (Velkov et al. 2005). A lab study showed some mortality in monarch caterpillars that were fed milkweed leaves covered with Bt corn pollen. Although it was observed that more eggs are laid in and near cornfields than other environments. There was no significant difference in survival between milkweed plants in Bt cornfields compared to non-Bt cornfields. Studies showed lower monarch caterpillar survival in insecticide treated fields compared to untreated fields planted with Bt corn hybrids (Peairs, 2013). So while the Bt corn pollen is toxic to the monarch butterfly at the caterpillar stage, the alternative of using insecticides is just as detrimental to them.

Non-target species

Insecticide use is lowered by the use of Bt corn. If the main pests are susceptible to Bt toxins, natural enemies will be less affected by exposure to these chemicals. Since the target pest is eliminated from the crop by the Bt toxin, any natural enemy that relies on the pest could be negatively affected. Indirect effects could result in prey being smaller, sicker or less palatable after feeding on Bt corn. Natural enemies that feed on pests that have ingested the Bt toxin may be negatively affected by the toxin. A study in choice feeding allowed a *Chrysoperla carnea* to choose between *Spodoptera littoralis* (target pest) fed Bt corn and S.

littoralis fed non-Bt corn. The *C. carnea* showed a significant preference for *S. littoralis* fed non-Bt corn (Velkov et al. 2005). If non-Bt corn was planted near the Bt corn there should be no significant effect on mortality of natural enemies.

Soil

Some experts worry about the possibility of the Bt corn plant leaking delta endotoxins into the soil and damaging mycorrhizae, rhizobia and other microorganisms involved in litter decomposition and nutrient cycling. Delta endotoxins from corn enter the soil from root exudates and post-harvest residues. The toxin binds to the humic acid in the soil reducing its biodegradability. This means that the BT toxins could bioaccumulate in soil. This could pose a hazard to non-target organisms but also enhance the control of target pest insects (Velkov et al. 2005). In field studies carried out by Zwahlen et al. (2003), degradation of the cry1Ab toxin was investigated. The first field study, a tillage system was investigated. During the first month there was no degradation of the toxin but during the second month the toxin decreased in concentration to approximately 20% of its initial value. In the second field study, a no tillage sytem was used. The concentration of the toxin decreased to 38% of its initial value without delay. After 200 days, only 0.3% of the initial concentration of the toxin remained. So this demonstrates that delta toxins do leak into the soil but they degrade rapidly. Although the implications for various soil organisms are unclear, Bt is a very common soil bacterium. It is likely that exposure of the organisms to Bt toxins is common. No conclusive evidence has been gathered indicating significant direct or indirect effects of Bt corn on the soil environment (Velkov et al. 2005).

Threat to Humans

Since farmers began growing GM crops in1996, there has been no conclusive evidence of harm to humans. The main issue with regards threats to human is whether the Bt corn will introduce a new allergen. Some experimental transgenic plants have caused allergic responses. In the USA the EPA requires several food allergen tests as part of the registration process for transgenic crops containing pesticidal substances. One of the first tests measures the length of time that the potential allergen survives in an acid environment. Longer survival times indicate a higher chance of surviving the digestion process and being absorbed into the blood stream. This is the first step in allergenicity. Delta endotoxins by the Bt corn produced are all rapidly broken down in the stomach (USA EPA, 2014). Thus, they are not potential food allergens.

Contamination

Bt corn pollen can contaminate adjacent non-Bt corn crops. The effects of Bt corn pollen on Lepidoptera larvae can be observed at least 10m from Bt corn field borders (Velkov et al. 2005). Organic producers would have a problem with this, as if their crops were contaminated with Bt corn their produce would not be considered organic. Planting at least 150 feet apart from Bt corn should avoid this problem. This introduces the idea of refuge areas. Refuge areas work as a solution for cross contamination of pollen aswell as for the worry of insect resistance. Insects are building up a resistance to Bt crops being grown over approx. ten years, but insects also build up resistance to insecticides. Resistant management strategies need to be put in place to prevent this from happening. This can be done through using refuge areas. Refuges delay resistance by providing insects resistant to GM crop to mate with susceptible insects (Manachini, 2006). The Bt crop can certainly cross contaminate but there are simple solutions that can be put in place to protect the biodiversity of Italian farmland. These include crop rotations and refuge areas (Manachini, 2006). Crop rotation is a method used regularly by many farmers so would not impose much extra labour.

Other Countries

Austria, Hungary, Greece, Luxembourg and Germany have banned the cultivation of Bt corn but yet are still importing it. This raises the question as to whether these countries actually disagree with GMOs? Or is it another case of not in my back yard? France had previously banned the cultivation of GMO corn but in 2011 the French farm ministry's ban on MON810 was deemed illegal by the European Court of Justice and the French Conseil d'État (Agrimoney, 2011).

Conclusion

There are many concerns regarding Bt corn. Many are incorrect and have come from inconclusive or incomplete studies. Bt corn is not harmful to humans. The promoters in the inserted plasmids are no longer antibiotic resistant and the Bt corn will not introduce a new allergen according to the USA EPA. With regards Biodiversity, there is a lower survival rate for the monarch caterpillar on insecticide treated fields than in Bt corn fields. Also, natural enemies when given the choice, prefer non-Bt corn fed *S.littoralis*. So as long as there is non-Bt corn to feed on there should be no significant impact on natural enemies. Delta endotoxins are released into the soil by Bt corn but they have been shown to degrade rapidly.

If the correct resistant management strategies are put in place, Bt corn does not pose a problem. Space between fields of Bt corn and non-GM products is required to prevent cross contamination. Also, non-Bt corn needs to be grown nearby Bt corn so that natural enemies of the target pests of Bt corn do not decrease. If the correct measures and regulations are put in place, the insect biodiversity in Italy will not be affected. France encountered similar problems with GMOs and it is now legal to cultivate GMOs in France. This is a positive outlook for the future of GMOs and Italy should look to France as an example. After the research I have conducted, I believe that Bt corn should be grown in Italy and that the farmers who had their fields destroyed should be reimbursed.

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