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REVIEW OF BIOLOGICAL IMPACTS OF GENETICALLY ENGINEERED CROPS AND NEONICOTINOID TREATED SEED USE ON STATEN ISLAND

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ABSTRACT

Genetically modified organism (GMO) crops particularly Roundup Ready Crops have been widely used in commercial agriculture in the United States in general and Staten Island in particular. However, its use has promoted concerns about the potential environmental effects of this technology. Therefore, this work was initiated to review impact of GE crops and Neonicotinoid to biodiversity, special focus on bees, birds, and super weeds development at Satan Island. Glyphosate herbicide is now widely used for growing Roundup Ready crop, like maize and soy bean. Scientists reported that using glyphosate herbicide by far better than using the previously used herbicide to the environment and biodiversity. It is also known that super weed may develop through gene flow from Roundup Ready Crops to its wild relatives and develop resistance against roundup. However, this might not be a problem in Staten Island where there is no wild relative species for widely grown Roundup Ready Crops like corn and alfaalfa.With regards to Neonicotinoids, it has lower toxicity to mammals like birds, and fish than other non-target insect species specially bees and other pollinator. The effect of Neonicotinoids to non-target species can be minimized using Fluent Agent in seed coating the which reduces dust contamination. Therefore, the use of Genetically Engineered Crops and Neonicotinoid Treated Seed needs special care and management in order to minimize its damage to non-target insect species.

Keywords: Genetically engineered crops, GMO, Neonicotinoid, Roundup ready crops.

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1. INTRODUCTION

According to The American Heritage® Medical Dictionary (2007) "Genetically modified organism (GMO) is an organism whose genetic characteristics have been altered by the insertion of a modified gene or a gene from another organism using the techniques of genetic engineering." This techniques has enabled the insertion of genes from biologically unrelated species, allowing the production of genetic engineered crops that are resistant to nonselective herbicides containing the active ingredient glyphosate (GLY) or glufosinate-ammonium (GLU) (Devos *et al.*, 2008). Genetically Modified Organisms (GMOs) play a significant role in agricultural sector to maximize yield through producing new varieties which are resistant to herbicide, like Roundup Ready corn and Roundup Ready alfalfa, and pest resistant like Bt Corn. However its use is becoming a continuing controversial issue among scientists and nations. It is common to see Anti-GMO advocates protest to force governments to establish laws that ban use of GMOs in most countries like USA. Their major concerns are:GMOs have not been adequately tested to prove safe to our health and environment, genetic contamination, superweeds development, and herbicides use increments. However there are no significant problems observed so far except some individual experience an allergic reaction upon eating GMOs (Key *et al.*, 2007). There is also growing public issue that using GMOs increase the use of herbicide (e.g Roundup) and neonicotinoids insecticide (primarily clothianidin and a closely related

compound, thiamethoxam) as seed treatment which affects the environment and biodiversity. They argue that neonicotinoids contaminates surface and ground water as well as soils, which kills non-target species such as bees, butterflies, and birds. Recently the Center for Food Safety, the Public Employees for Environmental Responsibility, Beyond Pesticides, and the Center for Biological Diversity are currently petitioning the U.S. Fish and Wildlife Service to immediately ban both GMO crops and neonicotinoids on National Wildlife Refuges, citing that these practices cause significant environmental harm. This review work will assess the impact of GMOs and neonicotinoids to plant and animal species on Staten Island, an agricultural property owned by The Nature Conservancy (TNC) with an objective to promote wildlife-friendly farming.

2. OBJECTIVES

2.1. General Objective

Conduct a review of scientific literatures and provide a summary report with management practices and research recommendations.

2.2. Specific Objectives

1) To make an annotated bibliography of research conducted on the biological effects of GMO (specifically Roundup Ready corn and alfalfa) and neonicotinoid seed treatments (specifically clothianidin) in Satan Island.

2) To review the impacts of these practices on bees, butterflies, and birds in Satan Island

3) To review the potential impact of GMOs on the creation of superweeds in Satan Island.

4) To provide a written synopsis of the applicable research, some initial recommendations for future crop management in light of any identified concerns, and a description of knowledge gaps that would require future study.

3. SITE DESCRIPTION

Staten Island is located within the Delta between the North and South Forks of the Mokelumne River, near Walnut Grove in San Joaquin County. The island is owned by The Nature Conservancy and is considered part of the Cosumnes River Preserve, however it is managed as a component of the Delta Project. The island is currently operated by Conservation Farms and Ranches, Inc., a non-profit affiliate of TNC.

Staten Island is characterized by expanses of deep organic peat soils reclaimed from the marsh habitats that formerly typified the Delta. Major crops grown in the Delta include corn, grain, hay, sugar beets, alfalfa, tomatoes, asparagus, and safflower; various fruits are also raised here, as well as some livestock. Crops currently grown on Staten Island include corn, triticale, alfalfa, potatoes, and irrigated pasture.

4. IMPACT OF USING GE MAIZE IN THE WORLD IN GENERAL AND STATEN ISLAND FARM IN PARTICULAR

The adoption of GE crops have been increasing over time in many countries. According to Barrows *et al.* (2014) the genetically engineered crops were quickly adopted following commercialization in 1996. By 2010, genetically engineered crops were annually planted across140 million hectares in 29 countries. The adoption of four principal genetically engineered crops (corn, soybean, cotton and rapeseed) accounted 42 percent ofland. The adoption of Roundup Ready crops has increased dramatically because of low cost, simplified, more flexible and selective weed management options provided by the use of broad-spectrum, intrinsically non-selective herbicides. In 2006, approximately 70 million hectares were commercially planted with genetically modified herbicide resistant (GMHR) soybean, cotton, oilseed rape (canola) and maize worldwide (GM stacked events excluded; Service2007).

The area of GMHR crops comprised 60% of soybean, 30% of cotton, 20% of oilseed rape and 15% of maize plantings (Duke and Cerdeira, 2005; Gianessi, 2005; Beckie and Owen, 2007). However this rapid rate of adopting Roundup Ready crop creates major concern for the safety of our environment and health among scientists and public. The major argument is the use of Roundup Ready crops increases the amount of herbicide use over time, which may have a negative impact to the our health and the environmentas well as the creation of super weed (Devos *et al.*, 2008). However, the use of glyphosate herbicide is by far better that the previous used chemicals which may have more negative impact to the ecosystem. Most scientists argue that using roundup ready crop has no significant effect to the environment as well as to ecosystem as compared to the previous used herbicide chemical. These are some advantages of using glyphosate herbicide,

1, Increased effectiveness of glyphosate reduced the need to use other chemicals of with higher environmental and safety concerns (i.e. Accent, Matrix, Shark, Banvel)

2.Without Roundup Ready corn, more chemical treatment was needed to control weeds (i.e. more pounds of material)

3.The use of glyphosate over other chemicals lowers health and safety concerns with handling, and leaves less build-up in the environment

4.With higher effectiveness of weed removal, less tillage is needed to control weeds, reducing greenhouse gas emissions

Most people believe that herbicide resistant weeds developed through gene flow from Roundup Ready cropsto wild relatives or resistance development to herbicides through time. Herbicide resistance through gene flow might not be relevant to Staten Island where there is no wild relative species for corn and alfaalfa. However, it is known that weed resistance occurs mostly when the same herbicide(s), with the same mode of action, have been applied on a continuous basis over a number of years. This might happen not only for Roundup but to other herbicides as well. According to reports from weed science (www.weedscience.org),there are 24 weed species that are currently 101 ??? resistant to glyphosate, compared to 129 weed species resistant to ALS herbicides and 70 weed species resistant to triazine herbicides, such as atrazine.Several of the confirmed glyphosate resistant weed species have also been found in areas where no Roundup Ready crops have been grown. For example, there are currently 14 weeds recognized in the US as exhibiting resistance to glyphosate, of which two are not associated with glyphosate. Therefore herbicide resistance in weed is not associated with GE crops, rather the inappropriate use of herbicide chemical and GE crops.

5. THE IMPACT OF USING NEONICOTINOID PESTICIDE

Neonicotinoids are among the most effective insecticides for the control of sucking insect pests such as aphids, whiteflies, leaf- and planthoppers, thrips, some micro lepidoptera and a number of coleopteran pests. Furthermore, they constitute effective tools for controlling parasites of companion animals/cattle and hygiene pests such as cockroaches, houseflies and termites (Jeschke and Nauen, 2005; Tomizawa and Casida, 2005; Elbert *et al.*, 2008; Goulson, 2013). There are seven types of neonicotinoid insecticides on the market i.e, imidacloprid, thiacloprid, thiamethoxam, nitenpyram, acetamiprid, clothianidin and dinotefuran (Jeschke *et al.*, 2011; Goulson, 2013). Neonicotinoids are a unique chemical class for sucking-insect pest control owing to their broad spectrum of activity that make the neonicotinoids the most rapidly expanding insecticidal class (Elbert *et al.*, 2008). They control pest populations resistant to conventional insecticides and exhibit long-lasting residual effects, especially in seed-treatment and soil application (Jeschke and Nauen, 2005). Excellent plant virus vector control, high systemicity and versatile application methods, combined with high operator and consumer safety, make these products ideal tools for modern agriculture (Elbert *et al.*, 2008) as compared to the organophosphorous insecticides. However it

has its own side effect like longer persistence, high water solubility, runoff and leaching potential as well as their very high toxicity to pollinators are placing them under increasing public and political scrutiny, especially now that they have become the most widely used pesticides in the world (Mineau and Palmer, 2013).

5.1. Neonicotinoids Effect on Bees and Other Beneficiary Insects

The use of neonicotinoid insecticides for corn production is very common in USA. For example in Staten Island, there is over 6,000 acres of corn produced, and all the corn seed has previously been treated with neonicotinoids (Personal communication). And also, The amount of using this insecticide is increasing time to time (Tomizawa and Casida, 2005). However, there is a growing public concern about the neonicotinoid insecticides negative effect to bees population and other pollinators. Because neonicotinoid insecticides are absorbed into the plant, neonicotinoids can be present in pollen and nectar, making these floral resources toxic to pollinators that feed on them (Hoopwood *et al*., 2012).

The use of neonicotinoids may have negative effects on these non-target species if early-season leaf-feeding occurs in the field (Moser and Obrycki, 2009). Laurino *et al.* (2011) indicates thatsublethal doses of neonicotinoids on honey bees has a significant effect on bee death and several neonicotinoids show very strong toxicity to pollinating insects and in particular to the honey bee (ApismelliferaL.), causing also other effects which are seldom easily identifiable, such as behavioural disturbances, orientation difficulties and impairment of social activities. A report from Hoopwood *et al.* (2012) indicates that Neonicotinoids can persist in soil for months or years after a single application and this contaminates untreated plants or wild bee forages through dust particle which results in some impact on bee populations. However Staten Island has recently tried to reduce dust contamination by using the new seed coat Fluency Agentfrom Bayer.

The Fluency Agent helps reduce the amount of total dust and further minimizes the amount of active ingredient potentially released in treated seed dust during planting. By reducing seed dust, Fluency Agent reduces the risk of exposure to foraging honey bees and other pollinators if they come in direct contact with the dust." (from Bayer's product sheet) The seed lubricants help reduce friction and improve uniformity of planting, however I'm not sure if they actuallyincrease the efficiency of the neonicotinoids themselves.

5.2. Neonicotinoids Effect on Birds

According to the report of Tomizawa and Casida (2005) the Neonicotinoidshave low toxicity to mammals (acute and chronic), birds, and fish, because of their ability to detoxify it and the neonicotinoids have higher selectivity factors for insects versus mammals than most insecticides, apart from pyrethroids. However reports from Mineau and Palmer (2013) and American Bird Conservancy (2013) have another story indicating that the neonicotinoids are lethal to birds as well as to the aquatic systems on which they depend. They argue that one of the reasons neonicotinoids are so commonly used is because they are promoted as being non-toxic to vertebrates, howeveraccording to Tomizawa and Casida (2005) a single corn kernel coated with a neonicotinoid can kill a songbird.This is the common problem for most farms, because seed-treatment chemicals are widely available to birds and the seeds are never fully covered with soil, making them easy to find by foraging birds. Spills are commonplace with current machinery. This may not be relevant to Staten (and other similar farms) that use more advanced newer machinery that minimizes spills and has improved accuracy of planting each seed underneath the soil.

And many species have the ability to scrape and dig for planted seed. Birds(e.g.,blackbirds and other songbirds Sandhill cranes are not present during the planting season. They are migratory and have left Staten by mid- to late-March in order to head to their breeding grounds further north.) that exist in the farm during planting are

more vulnerable to these chemicals. Otherwise most migratory and waterbirds will not be exposed to these chemicals directly and would be safe.

6. CONCLUSIONS

They advocatethat GMOs have not been adequately tested to prove safety because GMOs may have harmful effect to our health as well as to the environment. It is difficult to generalize all GMOs will bring problems to us. There are no significant problems observed so far except some individual experience an allergic reaction upon eating GMOs (Key *et al.*, 2007). However, it may have some side effects just that of other technologies, like medicinal drug, pesticide, fungicide, etc. do possess. Though GMOs is not accepted by some scientist, it has a significant importance in the field of agriculture because the growing population needs more food and there is no land to expand and increase productivity. Therefore to feed the growing population, the agriculture department of most countries needs to promote using GMOs for enhancing crop productivity.

In conclusion, though some scientists disagreewith the utilization of GMOs, it continues to be produced and consumed in most part of the country. Because of it various advantage over conventional. First, GMOs are very productive and will contribute in combating food shortage in most parts of the world. Second, GMOs are important for adapting the climate change by producing compatible varieties to the present situation. Third, it is helpful to reduce malnutrition in developing country through producing new variety which is reach in vitamin, mineral or proteins. Fourth, it is helpful to develop new varieties which are resistant to diseases and pests very quickly and helps us to avoid use of fungicide and insecticide for control. Fifth, it contributes the current burning issue of environmental issue through producing biodegradable PHB with 100 % replaces the use of polyethylene. Therefore, it is very difficult to underestimate the values of GMOs that play in the real world in which its advantage clearly seen. However, it needs some impact assessment work to see the effect of GMOs to the environment and human health to convince those GMOs protester and start supporting the application of GMOs.

I believe that this review work is not fully enriched with many research studies from different perspectives, and it is also supported by very little preliminary interview with farmers and farm managers, as well as little field observation of Staten Island. Therefore the information provided in this review work is to give an overview or highlight of the impact of GE crops and Neonicotinoids and future recommendation to be taken. In addition, due to shortage of time, I could not get time to explore and include the research achievement done in the study areas before. There was no documented information with regards to the effect of GE crops and Neonicotinoidson to Staten Island. This review was also done during spring season where there were no migratory birds,and it was impossible to see some forage crops for birds and bees to make some preliminary survey. Therefore, this paper is not sufficient enough to use for setting new or revised policies and also the recommendation made below is totally based on the experiences that I found in research publications and my personal analytical inputs.

7. RECOMMENDATIONS

It is clear that even among scientists, the argument of using GE crops and Neonicotinoid insecticides is continuing as a crucial issue and no tangible agreement has been reached so far. It is generally true that any technology has both good and side effects, however it is crucial to know the negative side effects to determine remedies and proper usage of the technology. The following points have to be clear in order to take action on the use of GE crops and Neonicotinoid in Staten Island.

1. Detailed survey work would be required to determine the status of plant and animal species (type, density, population number, population trend analyses, etc,) as well as the aquatic ecosystem before and after the use of GE crops and Neonicotinoidsstarted in Staten Island, in order to see the impact of these practices.The survey also

should include the trends of herbicide use between hervicide resistance (HR) GE crops and conventional crops, the existence of new weeds in the farm, and bird, bee, and aquatic animal populationsbefore and after the farms started using GE crops and Neonicotinoids.

2. Monitoring the quality of irrigation, drainage water and groundwater is crucial. Specially, the drainage water has a potential to contaminate the river with herbicide and insecticide residues and needs to be disposed of properly to protect the safety of aquatic birds and other aquatic species.

3. Investigation of the level of active ingredients of glyphosate and neonicotinoids residues in plant residue, soil, irrigation and disposal water, pollen and nectar of bee's wild forage, etc to set the minimum trash hold allowable.

4. Staten Island needs to revisit the main purpose of growing GE maize and alfa alfa and come up with better alternative. Staten Island has to do research work to determine the best crop type, either GE or non GE, which is environmentally friendly and also that give better feedandhabitat to the migratory birds.

5. Investigate the type of HR weeds, their status, mechanism of resistance, and their impact to the ecology.

6. It is also good idea to collect best practices of other national or international wildlife Refuges.

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