Department of Biosystems and Agricultural Engineering
MICHIGAN STATE UNIVERSITY

# Microbial vs. Chemical Pesticides: An Agroecological Analysis

Alexis Sawicki, Emily Gatrell, MeiLi Papa, Liliana Valkner

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Dr. Safferman

## Introduction

As the world population exponentially increases, the need to feed this growing population is as important as ever. Crops are an integral source of calories as an estimated 55% of the world's crop calories are eaten by people [1]. As seen in figure 1, United States' corn yield has been steadily increasing; to aid in this, farmers began using chemical pesticides in the 1930's to combat pest damage to crops [2]. Even though chemical pesticides are highly effective at increasing crop yield, there are harmful consequences for their extended use.

Even with the dangers pesticides pose to both the ecosystem and humans, they increase crop productivity and protection and increase quality of food [3]. Because the benefits of pesticide use are so extensive, it is necessary for alternatives to be found. Research is being done into microbial pesticides as these could potentially become a standard alternative to chemical pesticides. One that has shown great promise is a pesticide that utilizes *Bacillus thuringiensis* (Bt), where treated plants contain the Bt toxin and crystal that kills specific insects.

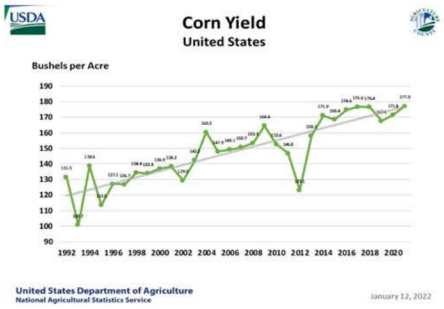


**Figure 1**: Average corn yield in the U.S from 1992-2020 in bushels per acre.
Photo credit: USDA - National Agricultural Statistics Service - Charts and Maps - Corn: Yield by Year, US

## Sensitive Unit

Pesticides have been utilized for decades to help with the quality and quantity of crop yields. Even so, many negative effects have been observed from their wide use. Several prevalent examples include [4]:

- Impacts on human health
- Contamination of air, soil, and animals
- Surface and ground water contamination

Pesticides is a very overarching term, since different types of pesticides have different purposes.

- Some of the most common types are:
  - Insecticides
  - Fungicides
  - Herbicides
  - Nematicides

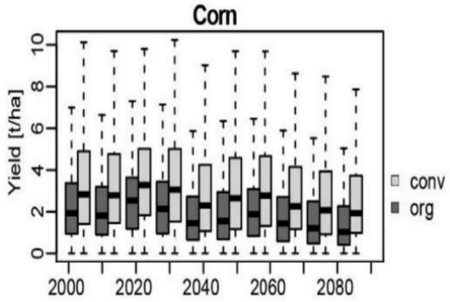


**Figure 3:** Simulation and comparison of corn production when conventional and organic methods are utilized.
Photo credit: https://www.mdpi.com/2073-4395/11/7/1300

Shown above in figure 3 is a comparison of crop yields when growing corn conventionally or organically. These predictions show how significant the use of pesticides are when looking to the future and worrying about feeding the growing population.

## Process Description

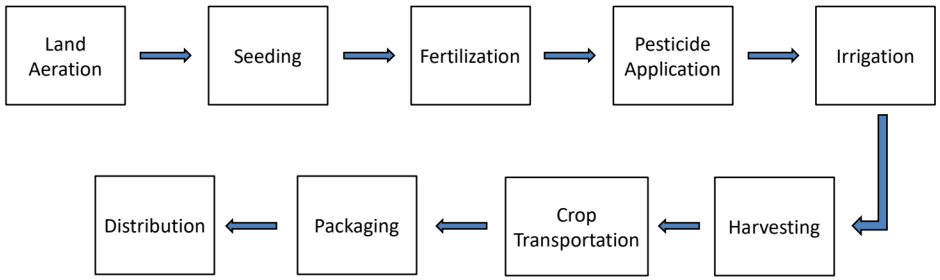


**Figure 2**: The process of crop farming beginning on the farm and ending up in stores for consumers.

## Impact Eco. Services

Chemical pesticides are harmful to the environment, and are known to harm groundwater, surface water, and soil. When chemical pesticides leach into the soil, they cause native microorganism populations to decline heavily [5]. The use of a biopesticide such as Bt could aid in preventing the decline of microbial organisms in soil as well as reducing other adverse effects of chemical pesticides.

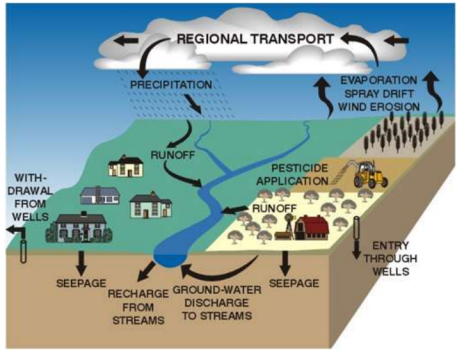


**Figure 4**: Pesticide movement through the environment.
Photo credit: http://pubs.usgs.gov/fs/fs03400/

### General Info regarding Microbial Pesticides:

- Less toxic than traditional pesticides.
- Biopesticides such as bacillus thuringiensis only target one specific pest.
- Able to maintain high crop yield and cut down on typical pesticide use.

### Environmental Effects:

- Bt remains dormant in natural soil conditions and stays on the top few inches of soil.
- Bt. Toxins break down quickly, with one study having only 12% left after 15 days [6].
  - Bt is known to break down when exposed to sunlight and acidic soil [6].
- Bt is nontoxic to most wildlife and does not greatly harm the ecosystem.
  - Studies have shown that rats given large doses of Bt have no adverse reaction.
  - One strain of Bt, aizawai, is toxic to honeybees and water fleas.

### Effects on Human Health:

- Studies show that bacillus thuringiensis has no toxic effects on humans.
  - Non-carcinogenic
  - If inhaled, only causes mild irritation.

## Research

### Proposed Use of Microbial Pesticides:

Microbial pesticides such as Bt, are effective at ridding plants of insect harm, while also being less harmful to the environment.

*Bacillus thuringiensis* treated plants contain a Bt toxin and crystal. The Bt toxin binds to receptors in insects' stomachs that signal it to stop eating, and the Bt crystal causes the gut wall to break down, ultimately killing the insect [2].

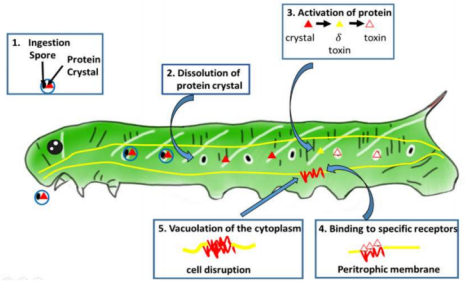


**Figure 5:** *Bacillus Thuringiensis* mode of action.
Photo credit: https://www.researchgate.net/figure/Mode-of-action-of-Bacillus-thuringiensis-in-Lepidopteran-caterpillar-1-ingestion_fig1_318039006

**Hypothesis:** The use of microbial pesticides is less damaging to the environment than chemical pesticides.

### Objectives:

1. Evaluate the effectiveness of microbial pesticides (*Bacillus thuringiensis*)
2. Evaluate the environment impact for microbial and chemical pesticides

### Task:

1. Plant one crop field using chemical pesticides and one using Bt
2. Harvest and compare crop yield and ecological impact

### Analysis:

- Evaluate the relative effectiveness, crop yield, and ecological impact of each type of pesticide and assess the benefits of each.
- Microbial pesticides are not mainstream, and more research must be conducted before feasibly implementing a system.

## References

[1] B. Plumer, "How much of the world's cropland is actually used to grow food?," *Vox*, Aug. 21, 2014. https://www.vox.com/2014/8/21/6053187/cropland-map-food-fuel-animal-feed#:~:text=Crops%20grown%20for%20food%20%28green%29%20versus%20for%20animal

[2] "Synthetic Pesticides," *www.bt.ucsd.edu*. http://www.bt.ucsd.edu/synthetic_pesticide.html#:~:text=The%20use%20of%20synthetic%20pesticides%20in%20the%20US (accessed Apr. 22, 2022)

[3] L. Rasche, "Estimating pesticide inputs and yield outputs of conventional and organic agricultural systems in Europe under climate change," *Agronomy*, vol. 11, no. 7, p. 1300, 2021.

[4] M. Wasim Aktar, D. Sengupta, and A. Chowdhury, "Impact of pesticides use in agriculture: their benefits and hazards." Mar-2009.

[5] W. Aktar, D. Sengupta, and A. Chowdhury, "Impact of pesticides use in agriculture: their benefits and hazards," *Interdisciplinary Toxicology*, vol. 2, no. 1, pp. 1–12, Mar. 2009, doi: 10.2478/v10102-009-0001-7.

[6]"How might I be exposed to Bacillus thuringiensis (Bt)," 2015. [Online]. Available: http://npic.orst.edu/factsheets/BTgen.pdf