The Relationship Between Pesticides and Carbon Emissions in Industrial Agriculture

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Abstract

Agriculture is a large, profit-driven industry, and many methods used in modern agriculture are harmful to animals and the environment in order to obtain the largest yields and profit. Many studies demonstrate the ways in which agriculture affects land and ecosystems, but one aspect of agriculture that is not often studied is the way in which pesticides directly affect carbon emissions. In order to study the effect of pesticides on carbon dioxide emissions, data was collected on the amount of fungicide, herbicide, and pesticide used on soybean in each state. The carbon emissions due to agriculture were then found for each state and an equation was used to find the amount of carbon released due to pesticides. Through this, it was found that herbicide and fungicide had positive correlations, showing that the more each pesticide used, the more carbon dioxide was released. Insecticide, on the other hand, had a slightly negative correlation, driven by one outlier state. When pesticide amounts were compared with profit, the same trends were shown, respectively. When profit and carbon emissions were compared, it showed that the more profit made, the more carbon is released. This data shows that agriculture is very profit-oriented, explaining the use of many harmful substances as a means to improve crop yield. In order to satisfy profit, productivity, and lower carbon emissions, more sustainable methods of farming can be used. Some examples are integrated pest management (IPM), or organic farming. While these are the two most commonly used methods, more research must be done in order to find better methods and helpful technology.

Introduction

Agriculture is a large, profit-driven industry, and many methods used in modern agriculture are harmful to animals and the environment while trying to obtain the largest yields and profit. This usually leads to animal abuse (Fiber-Ostrow & Lovell, 2016), using toxic pesticides (Tudi et al., 2021), and harming the earth in numerous ways. Humans rely on agriculture to feed the population and livestock so heavily that the time needed to reflect on more environmentally sound and effective ways to practice agriculture is not taken. One example of this is the practice of slash and burn, which is highly destructive to ecosystems because it involves burning down an area of land to then clear it for livestock or agriculture (Chevalier, 1980). This not only harms the local ecosystem, but the environment as a whole by burning down trees which are a natural carbon sink and help to hold and reduce the amount of carbon in the atmosphere (Jarvis, 1995). By burning them down, we release tons of carbon back into the atmosphere but also take away natural systems to purify the air. Another way in which humans use harmful substances or practices for easy profit is the use of pesticides. Although pesticides are regulated, they are a fairly modern approach to farming and there are still long lasting impacts of pesticides which are still unknown (Persson et al., 2010). What is known as of now is that it has severe health impacts on animals and humans causing increased risks of cancer (Dich et al,. 1997). They also runoff into rivers, nearby land, and neighboring crops, affecting much more than the crops pesticides are intentionally sprayed on.

There are three main types of agriculture: industrialized farming, integrated farming, and subsistence farming. Industrialized farming as described above prioritizes high crop yields and profit over the environment and can be very destructive. Subsistence farming has the opposite goal, and uses its resources to farm at a very local level (Chibnik, 1987). Integrated farming is a compromise of these two contradictory practices. It values profit and yield, but uses the environment to its advantage (Wenhua et al., 1999). This is the future of agriculture since it allows for high crop yields, while remaining sustainable. The employment of more integrated farming would result in reduced amounts of pesticides, the rotation of land for different crops, and less carbon emissions.

Within integrative farming there are two common practices, integrated pest management (IPM) and organic farming. Out of the 911 million acres of total farmland nationwide in 2016, only one percent were organic, showing that there is a great lack in sustainable agricultural types. There are studies demonstrating the way in which agriculture affects land and ecosystems but one aspect of agriculture that is not often studied is the way pesticides impact carbon emissions, which is what I will study in this paper.

Methods

In order to collect data for this project, data for each variable were found which are: pesticides used for soybean per state broken down between herbicide, fungicide and pesticide (USDA/NASS 2021), carbon emissions in relation to agriculture by state (US EPA Greenhouse Gas Inventory Data, 2023), and agricultural profit per state (USDA Economic Research Service, 2021). To make sure that the data was consistent, all the data found is from 2020. In addition to this, an equation which determined that per bushel of soybean, 7.5 pounds of CO_2 are released was used (USDA, 2015). I used this equation to find the amount of CO_2 released in correlation to each state's use of pesticide.

The next step was to use R-studio to analyze the data. To test the normality, I used the Shapiro-Wilk's test. I then assessed the correlation between carbon emissions and each variable, using the Spearman rank-correlation test. This revealed/demonstrated how correlated the data sets are and if they have a positive or negative correlation.

Results

The state with the most amount of insecticide was Louisiana, while Illinois used the most amount of fungicide and herbicide.

A Significant correlation ($p < 0.001$, rho = +0.96) between the amount of herbicide applied, and carbon emissions was noticed, when assessed at the state level. A significant correlation between the amount of fungicide and carbon emissions ($p = 0.02$, rho = +0.62) was also found. The relationship when comparing insecticide amounts to carbon emissions ($p = 0.89$) was however not significant . A notable relationship between profit and herbicide (p, rho), and profit and fungicide (p) was also found, but not between profit and insecticide. Across all states, there was a significant relationship between profit and carbon emissions (p, rho).

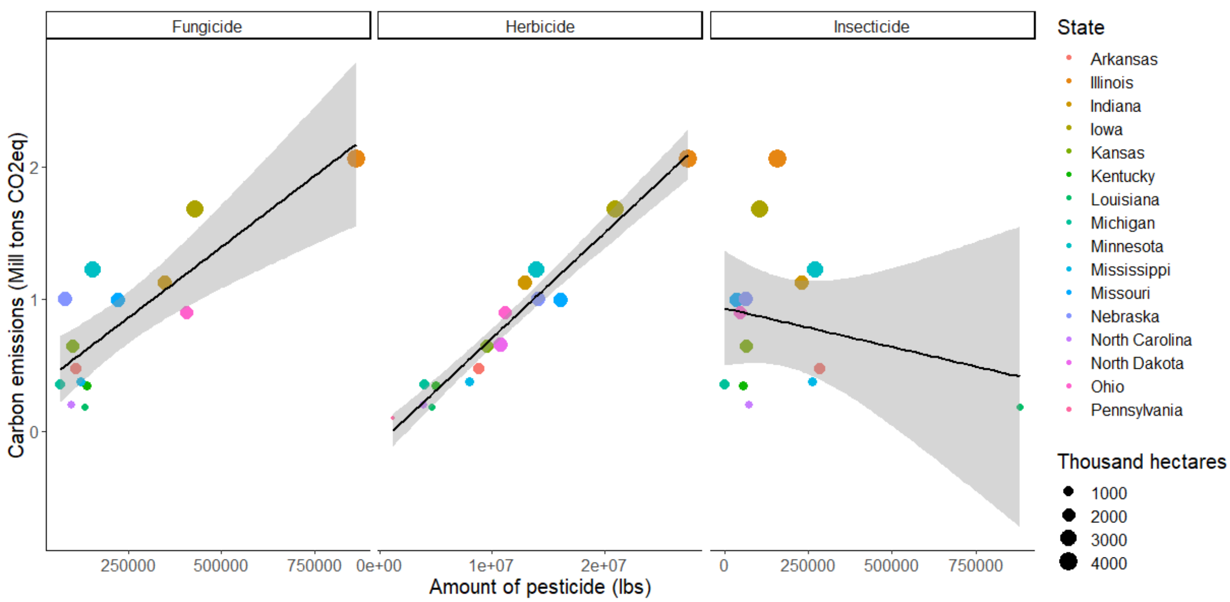

Figure 1. Above shows the amount of pesticide used in lbs in correlation to the amount of carbon each pesticide emits. There is a strong correlation for fungicide with p-value of 0.02 and a positive correlation with a rho value of 0.62. Herbicide has a p-value less than 0.001 and a positive correlation with a rho value of .96. Insecticide does not have a significant correlation with a p-value of 0.89.

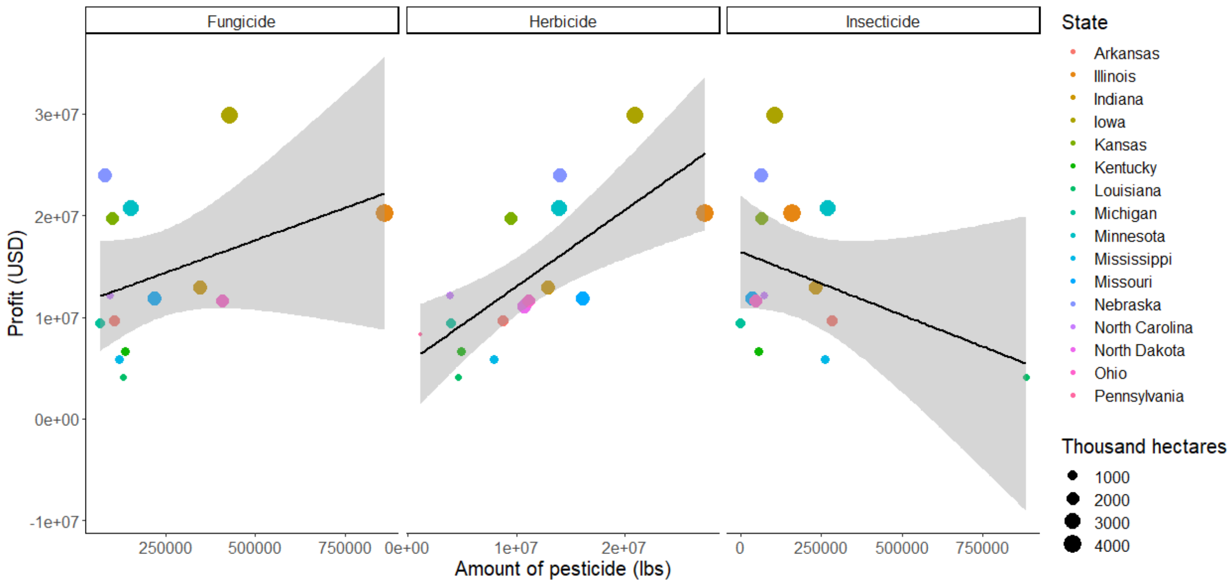

Figure 2. Above shows the amount of chemical pesticide in pounds in correlation to profit. There is a strong correlation between fungicide and profit with a p-value of .37 and a rho value of 0.26. Herbicide has a p-value of 0.001 and rho value of .74. Insecticide has no significant correlation and a negative rho value.

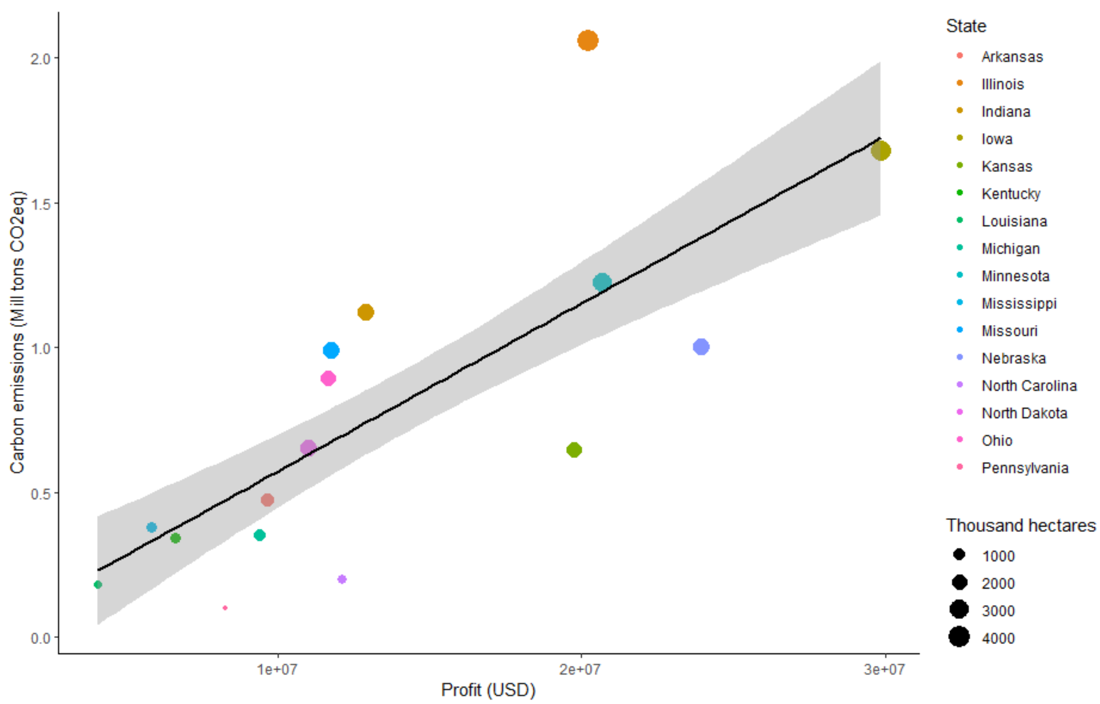

Figure 3. Above shows the correlation between profit each state made in USD for agriculture relative to the carbon emissions released for soybean per state. This graph has a p-value of 3.056e-12 and rho value of 0.75.

Discussion

When studying the correlation between the amount of pesticide used and carbon emissions found in Figure 1, I found that fungicide and herbicide both have positive correlations, while Insecticide has a negative correlation. While both fungicide and insecticide have significant margins of error, herbicide has a very small error showing that the more herbicide used, the more carbon is released into the atmosphere. Long & Tang (2021) also saw a positive relationship between carbon emissions and chemical use, including the use of pesticides and fertilizers.

A discrepancy that may be noticed in Figure 1 is that the more insecticide used, the less carbon is released. While this is the trend shown in Figure 1, it is due to Louisiana using an abundant amount of insecticide compared to the amount of soybean the state cultivates. Figure 2 shows how the amount of pesticide affects profit. The same trends are shown in this graph as in Figure 1. Fungicide and herbicide have a positive correlation, showing that the more pesticide used, the more profit is reached. Insecticide shows a decline, which is once again due to Louisiana using a lot of insecticide compared to the amount of soybean produced. This heavy use of pesticide in Louisiana compared to other states may be due to predation by the redbanded stink bug (*Piezodorus guildinii),* which increasingly acts as a pest to soybean production there (Bastola & Davis, 2018), and appears to be less susceptible to pesticides than other insects (Temple et al., 2013). Finally, Figure 3 presents how profit increases with carbon emissions. The upwards trend shows that the more profit made, the more carbon was released in the process. Figure 2 and 3 show the way in which agriculture values profit over the environment and Figure 1 shows the environmental impact that agriculture has due to its use of pesticides.

One of the greatest contributors to global warming are greenhouse gasses, notably carbon dioxide. Although carbon dioxide only makes up 0.04% of the atmosphere, it is a leading contributor to climate change. As carbon dioxide levels rise, the gas traps heat in the atmosphere through a process known as the Greenhouse Effect, leading to an overall warming effect. By increasing the amount of pesticides used on crops, specifically herbicide and fungicide, more carbon is released into the atmosphere, worsening climate change. In addition to this, pesticides have a direct effect on local habitats and ecosystems due to the chemicals used to kill and repel insects, animals, and fungi. These chemicals run-off into streams of water and groundwater. This results in endangering animal species by offsetting the food web, poisoning animals, amongst other side effects. The use of pesticides is not the only contributor of carbon emission within agriculture, but one problem amongst many others. One large contributor to carbon dioxide being released into the atmosphere is the practice of slash and burn which consists of burning down forests to create arable land. This eliminates large portions of forests and plants, which are natural carbon sinks.

The two most common methods used to reduce pesticide amounts are integrated pest management (IPM) and organic farming. IPM is a method that uses alternative pest controls, which is better for the environment and uses less pesticides by optimizing each dose (Jaquet et al., 2022). Organic farming does a better job of reducing pesticide use due to the fact that it doesn't allow the use of synthetic pesticides, maintains soil fertility, and closes nutrient cycles. Although the organic system seems ideal, it tends to produce lower crop yields and isn't adequate to fight against weeds. These two ways of farming are better for the environment compared to industrial agriculture, but in the case of IPM, it is insufficient. This is why research to help reduce pesticide use is so important . While the perfect system or method is still to be found, through research we can identify ways in which natural processes can benefit agriculture. Since the methods being tested are meant to change the way the world farms as a whole, researchers must also include farmers in their findings to see if these changes would be realistic for farmers (Jaquet et al., 2022).

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