Crops vs. wildflowers: effects of herbicide concentration on growth and survival

Abstract

This experiment was designed to simulate the effect of crop herbicide runoff onto neighboring species of wildflowers, as herbicide runoff can be detrimental to neighboring plant life. The herbicide 2,4-D negatively affects the growth of dicots while protecting monocots, such as many crop plants. A high concentration of 2,4-D has a strong negative effect on the growth and germination of plants, especially wildflowers. We hypothesized that crop plants will survive and grow better at a high concentration of herbicide than wildflowers. Using 30 seeds each of two crop species (radish and corn) and one species of wildflower (alyssum), we tested plant growth and survival across differing concentrations of herbicide. Our results show that the corn had the highest survival rate, and the alyssums had a significant lower rate of survival. Meanwhile, there was a significant effect of species, herbicide concentration, and the interaction among both on the height of the plant, though the only significant interaction was between the control to 25% group.

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Introduction

This experiment was designed to simulate the effects of different concentrations of 2,4-D on crop plants as well as the effects of runoff on differing types of wildflowers. 2,4-D, otherwise known as 2,4-Dichlorophenoxyacetic acid, has been one of the most popular and most affordable weed killing alternative since its introduction in the 1940's (cite). This type of herbicide, belonging to the phenoxy family, works as a pseudo-auxin hormone (Jervais et al. 2009). This herbicide attacks and kills broadleaf, dicot plants by causing the cells in the xylem to grow and divide rapidly, but does not affect monocot plants, such as grass or corn (Ganzel 2009).

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Application of herbicide on crops can also cause more harm than good; a study using different concentrations of 2,4-D found that corn plants with higher concentrations applied to it were more susceptible to insect and disease attacks (Oka, N. and Pimentel, D. 1974). Not only can the application itself be harmful, but herbicide runoff is also extremely common and affects not only the neighboring plant life, but also the local wildlife (Roy et al. 2003). Inability to

regulate and recognize the effects of these herbicides can have negative ecological effects on plant survival, seed production, flowering ability, and species composition at all trophic levels (Boutin et al. 2014). An example of this comes from a study regarding herbicide effect on milkweed germination, it found that higher concentrations of herbicides (oxyfluorfen, terbuthylazine, and mesotrione) had a dramatic effect on germination percentage, decreasing germination percentage and seedling root length (Radivojevic et al. 2016). This information can also be applied to corn germination, seeing as herbicides are commonly applied to corn at varying levels of the plants development. A study on the effects of 2,4-D on corn at varying levels of growth found that damage increased as the plant matured (Guzman and Wolf 1953). An additional study done on vegetation in tilled margins of fields containing herbicide resistant crops found that the application of herbicides on those plots had a significant negative effect on the plants ability to cover and flower (Roy et al. 2003). We hypothesized that the 2,4-D herbicide will have a negative effect on all plant species growth and survival. In doing so, we predicted that the herbicide will have a stronger negative effect on the wildflowers rather than the crops and also that there will not be a significant amount of change in crop and flower growth before the 50% concentration group.

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Methods

We grew two crop species of plant: 30 seeds of SeedWay brand hybrid sweet corn (*Zea mays*), from Idaho, USA and 30 seeds of SeedWay brand radish (*Raphanus sativus subsp. sativus*) from Lot# K3043, and two species of wildflower species: 30 seeds of Ferry-Morse brand alyssums (*Lobularia maritima*) from Massachusetts, USA and 30 seeds of Ferry-Morse brand California poppies (*Eschscholzia californica*) from Massachusetts, USA in the Knox College greenhouse

for a total of 17 days. The total number of seeds used was 120. Without imbibing them, we placed five seeds of each species into a petri dish of agar and 1 mL of water, keeping each species separate. The seeds remained in the agar until germinated, which was defined as the emergence of the radical. Once germinated, we transplanted the seeds from the agar to soil, separating the seeds into two seeds per pot. They were planted into the small seed starter pots filled with Miracle Grow potting soil. We separated the seeds into five treatment groups consisting of a control, 25% concentration, 50% concentration, 75% concentration, and 100% concentration of herbicide. Each treatment group had six seeds per species. We mixed the herbicide according to the manufacturer's guidelines, which were to mix three tablespoons of herbicide per gallon of water, or one and a half tablespoons per half-gallon of water. We treated that mixture as our 100% herbicide concentration. From this, we further diluted this mixture in order to make our 75%, 50%, and 25% concentrations. We applied 5 mL of the herbicide with a syringe directly onto the soil at the time of transfer. We recorded the total height of the plants from root to tip in centimeters after 17 days of growth. We analyzed the number of survivors with a Chi-Square Goodness of Fit Test with Microsoft Excel (n=90, d.f. = 2) and interaction of growth between the species and concentrations using a two-factor ANOVA test with GraphPad Prism (n=90, d.f=72). The California poppies did not germinate, and therefore will not appear in our results.

Results

There was a significant effect of both species and herbicide concentration on plant survival (X^2 =17.01, n=90, d.f.=89, p=0.0002). The alyssum had the lowest survivorship, with only six survivors (Figure 1). Although the corn had the highest number of survivors, it was not

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significantly different from the radishes. Therefore, it can be seen that the crop species have a significantly higher survivorship when exposed to any herbicide concentration than wildflowers.

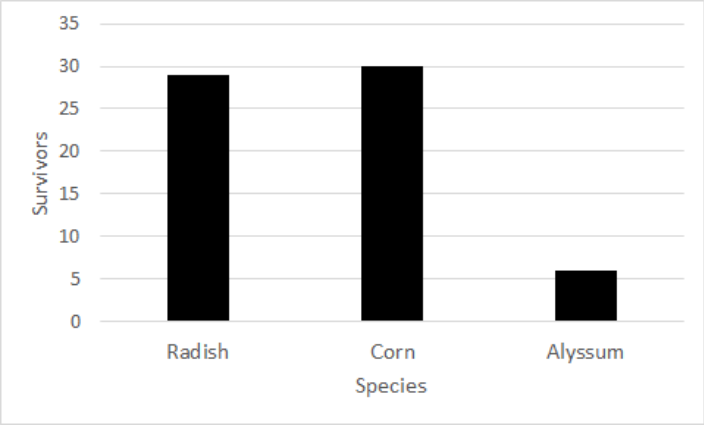

Figure 1. The number of surviving radishes, corn, and alyssum after 17 days of growth (n=90).

In regards to the height of the plants, growth was significantly affected by the plant species ($p<0.0001$), herbicide treatment ($p<0.0001$), and the interaction between the two ($p<0.0001$) (n=90) (Figure 2). However, although the difference between the control group and all the other treatment groups was significant ($p<0.0001$), the interaction between the other treatment groups among themselves (25%, 50%, 75%, and 100%) was not significant ($p > 0.05$).

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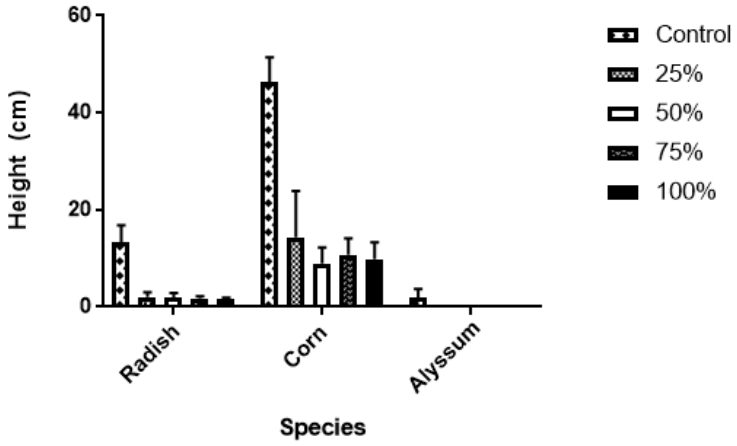

Figure 2. Average height of radish, corn, and alyssum (n = 30, 28, 30, respectively) after being exposed to differing concentrations of herbicide (0%, 25%, 50%, 75%, and 100%) after 17 days of growth. Error bars represent standard deviation.

Because there were no significant interactions other than the control treatment group to the first application of herbicide (25%), it can be seen that any amount of herbicide, no matter the concentration, had the same effect on plant height.

The corn was the most sensitive to the application of herbicide, though it had the highest overall survival and height (Figure 3). The slope of the interaction line of the corn is much steeper than those of the radish or alyssum, with a slope of -1.27 compared to a slope of -0.45 for the radishes and -0.076 for the alyssum.

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Commented [RK12]: A good conclusion to draw, but it belongs in the discussion, not the results.

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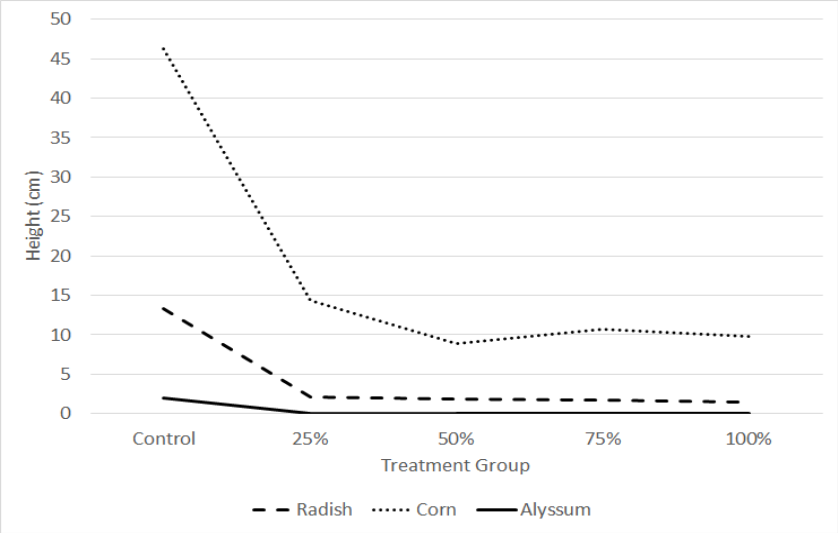

Figure 3. Interaction between average growth of radish, corn, and alyssum over a period of 17 days.

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The higher slope displays the sharper drop in height in corn from the control group to the group treated with 25% herbicide. This sharp drop in height shows that the corn had the most dramatic effect in height as a result of the application of the 25% herbicide.

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Discussion

We conducted an experiment to simulate the effects of crop herbicide runoff onto neighboring species of wildflowers. Our results show that although there is a significant interaction between herbicide concentration and species on height, the only significant interaction was among the control and 25% concentration groups. These results show that any concentration of herbicide after 25% has the same dramatic effect on plant growth. Also, the alyssums had a significantly lower survival rate than the two crop plants. Therefore, our results support previous research in that crop plants survived and grew better than wildflowers. This is

likely due to many crop plants being monocots and the herbicide 2,4-D selectively targeting dicots. Since many wildflower species, such as the alyssums, are dicots, this herbicide would have a stronger effect on their growth and survival than on the monocot crop species. An interesting thing to note would be the effect of the herbicide on the radishes, which are dicots. The most likely explanation of the success and survival rate of the radishes would be attributed to natural selection and the seeds being more self sufficient. We also applied a considerable amount of herbicide to the plants, 5 mL, which could have caused the higher concentrations to have an even more fatal effect. Previous research used parts-per-million measurements while we only diluted the mixture that was suited best for northern lawns. This could have easily contributed to the increased fatality as the concentration increased. In addition to this, the crop seeds, unlike the alyssums, were genetically modified via artificial selection over the decades to be more durable towards herbicides (citation). These seeds are much bigger and full of nutrients compared to the extremely small and delicate alyssum seeds. The interior surface area and storage capacity of corn seeds makes the possible capacity of the alyssum and the radish seeds dwarf in comparison (citation). This is could be an additional biological factor as to why the crop species survived much better than the alyssums.

In addition to our results supporting previous research, our results partially supported our predictions, as herbicide did have a stronger negative effect on the wildflowers rather than the crops. However, we predicted that there would not be significant negative effects on any of the plants before the application of the 50% herbicide. This was not supported by our results, as there was a significant effect of herbicide on the growth of all of the plants at the application of the 25% herbicide.

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Our California poppies did not germinate, resulting in only one species of wildflower being tested. We believe this is due to the poppies being placed in wet agar. They enjoy to grow in dry, rocky environments, therefore we believe that they did not have the correct environment in which they could easily germinate. The results of this experiment may have been different if there had been more data collected on other species of wildflowers.

In the future possible variables to test would be along the lines of smaller concentrations of 2.4-D to find the concentration border where there is a minimal effect on the plant itself but it kills the weeds around it. A future test branching off of the previous one mentioned would be testing the herbicide on patches of sod and yards to see the differences between how the native weed plants and the grass react to the herbicide. Further testing on how monocots and dicots react to 2,4-D would be helpful for finding the plants that are resistant to the herbicide and doing further testing on why that is. Previous research states that corn is particularly resistant to 2,4-D, which is peculiar because our results showed that it was the most sensitive to the herbicide out of all of the other plants tested. The corn's age might have been a significant factor as to why the herbicide affected it so much. Previous studies on corn and germination had found that the herbicide had a lesser effect on the corn the more mature it was (Guzman and Wolfe 1953). We applied the herbicide to the corn at a very young age, which could explain the stunted growth in the higher concentration groups.

In conclusion, our experiment supported previous research and some of our predictions about how wildflowers and crops would react to the herbicide 2,4-D. Overall, the flowers were more sensitive than the crops but they were all more sensitive than we initially thought. Further testing can be summarized as focusing on the lower concentrations of herbicide as well as testing on different maturities of both the crops and the wildflowers. The common appearance of

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herbicide runoff and drift in the agricultural world should be something that we all take notice of as it can severely damage the plants nearby. When spraying herbicide, one should be conscious of the possible repercussions onto their crops as well as the wildlife that exists outside of the plot.

Literature Cited

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Roy, D. [illegible] herbicide-tolerant crops. *The Royal Society*. 270, 1877-1883. [illegible] genetically modified