The effect of organic herbicide such as Acetic acid, Propionic acid, and Sodium Lauryl Sulfate on the fertility and climbing rates of *Drosophila melanogaster*

<u>Proposal</u>

Objective:

The purpose is to test the effects of different concentrations of organic herbicide on *Drosophila melanogaster*. The ideal concentration of herbicide that must be used for the benefit of the insect population in the environment may be determined after the results of the experiment are fully analyzed.

Justification:

This research is important because over the years, more farmers tend to use herbicides to protect their crops. Many "organic" food brands tend to use organic herbicides, which may be impacting our ecosystem negatively or positively. Insects are one of the main parts of our food chain, so it is important to assess if these herbicides are slowly decreasing the insect population. This test will be performed on fruit flies, which can help us make a connection between their survival rates and the survival rates of insects (as it is a model organism) in the ecosystem. Though, based on previous research, inorganic, lab-based chemical herbicides have a negative effect on the Drosophila climbing ability. These results could also be compared to this research because it would help determine if there is a difference between the use of organic and inorganic herbicides. Conducting this experiment would eventually lead to drawing conclusions if organic herbicides have a better impact on the ecosystem, and if the concentration alters the insect behavior.

Description:

The independent variable of this experiment is the type and concentration of each of the herbicides (Sodium Lauryl Sulfate, Propionic Acid, and Acetic Acid). The dependent variable is the *Drosophila melanogaster* climbing ability and the fertility rates. To conduct this experiment, first 3 different concentrated solutions for each of the herbicides would be created by mixing them in distilled water. Then, this would be added to the fly food in the climbing assay. Then, they would be timed for 30 to 60 seconds to determine the amount they climbed. Additionally, after a week, the number of fly pupae on the walls of the climbing assay would be counted as it is proportional to the fertility of the flies. These results would be analyzed to draw valid conclusions.

Limitations:

A major limitation in this project is that there may not be enough flies to conduct 10 trials. Instead, less flies might be needed to be added to each of the climbing assays, and thus providing less accurate results due to the lack in trails. Additionally, the number of females per climbing assay must stay constant, which may cause error due to their miniscule size. Also, a toxicity assay may be needed to determine if the concentrations of the herbicide used were enough to kill the stock of flies. And lastly, time is a major limitation because the lifespan of a fruit fly is only one to two weeks.

Feasibility Study

What resources are currently available and from where?

Personnel: Mr. Allshouse, myself

Equipment: iPhone camera to film fly movement – from myself

Supplies: Water – from ACL

Knowledge/skills: Prior knowledge on how to create different concentrations of a solution and how to handle equipment.

What additional resources are needed?

Personnel: None

Equipment: 10 3.5 - 6 cm tall test tubes to perform climbing assay in (9 samples + 1 control group) – from ACL

Supplies: 100 g Sodium Lauryl Sulfate, 500 mL Propionic acid, 100 mL Acetic Acid, 390 mL distilled water, 42.4 g light corn syrup, 28.5 g yellow cornmeal, 6.75 g yeast, 3.90 g soy flour, 2.25 g agar, Oregon-R-P2 strain fruit flies – from ACL

- SDS:
    - Sodium Lauryl Sulfate
    - Propionic Acid
    - Acetic Acid

Knowledge/skills: Need to know how to perform a climbing assay, how to make the fly food with herbicide, how to take care of the fruit flies, and how to statistically analyze the results.

Proposed Budget: Approximately $100 – Sodium Lauryl Sulfate ($20.10), Propionic Acid ($22.47), Acetic Acid ($10.80), and 2 stocks of Oregon-R-P2 Strain ($22.50 each).

Risk Assessment:

Sodium Lauryl Sulfate, Propionic Acid, Acetic Acid, and 10 test tubes would be used for this research. For handling Sodium Lauryl Sulfate, make sure to wear personal protective equipment/face protection; do not get in eyes, on skin, or on clothing; avoid ingestion and inhalation; and remove all sources of ignition. For handling Propionic Acid, make sure to keep away from heat, sparks, flame and other sources of ignition (i.e., pilot lights, electric motors and static electricity); use spark-proof tools and explosion-proof equipment; and avoid contact with skin and eyes. For handling Acetic Acid, take measures to prevent the build up of electrostatic charge; wash hands after handling; avoid contact with skin and eyes; do not eat, drink, smoke, or use personal products when handling chemical substances; do not inhale gasses, fumes, dust, mist, vapor, and aerosols; and follow good hygiene procedures when handling chemical materials. To prevent the test tubes from breaking, glassware must be handled with caution. If any of these chemicals spill or the test tubes break, children should be taken away from the broken glass and the place should immediately be cleaned up.

Alternate Idea:

To continue studying the effects of organic herbicides on the environment, a different model organism, such as aquatic worms, could be used to determine the impacts on aquatic life. If not, then the method of exposing the herbicides could be altered to using an aroma instead of increasing the concentration in the fly food.

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Background

After the Green Revolution, agriculture has been an important basis of the economy. The efficiency of the agricultural system has greatly increased as the use of fertilizers, pesticides, and herbicides. With the increase in these methods have increased the crop yield, there have been significant losses in biodiversity, soil degradation, and land transformation. Not only this, the increase in the chemical use of fertilizers and herbicides has increased the health problems in the global economy. Agriculture would continue to dominate the economy as the population continues to grow in the world. Furthermore, approximately 38% of the global land surface is used for agriculture (Altieri, 1999).

The most common problem that farmers face during agricultural production is weeds. Weeds are invasive plants that tend to spread at a relatively quick rate. According to the Weed Loss Committee, crop yield can decrease by up to 50% in *Zea Mays* L. due to weeds. The most common type of weed is known as the common chickweed, which is also known as *Sterallia media.* The chickweed has been recorded to be present in 60% to 88% of all farms in the United States. This plant tends to kill other plants by expanding its roots, and not providing enough space for the roots of the crop to grow. This causes a decrease in the amount of agricultural production, and thus farmers have decided to implement the use of herbicides to prevent these weeds from killing other plants (Singh, 2022).

Herbicides are chemicals used to control undesirable vegetation. Though, there are two main types of herbicides: organic and inorganic herbicides. Inorganic herbicides are made from a chemical that is synthetic, which has been created in a lab, such as Atrazine, Paraquat, or

Glyphosate. On the other hand, organic herbicides are created by naturally-occurring compounds in nature. According to the National Pesticide Information Center, only a small percentage of the number of herbicides present on the market are labeled “organic”. Additionally, organic herbicides may be preferred over inorganic herbicides due to their effectiveness. Organic herbicides tend to kill younger weeds faster compared to inorganic herbicides, especially in their cotyledon or first true leaf stage (Freidenreich, 2016).

There are two main classes of herbicides: contact and systemic herbicides. Contact herbicides are herbicides that only damage the plant tissue they come in contact with. Generally, these herbicides are really fast acting, though they may take multiple applications to completely damage the weed. On the other hand, systemic herbicides act through absorption from the roots. The vascular system of the weed carries the herbicidal compound, and thus slowly damages the plant. Though, this herbicide takes longer to work. Additionally, each of these classes have either selective and non-selective herbicides. Selective herbicides are herbicides that only focus on damaging a certain type of plant based on their metabolic process. For example, Bow and Arrow is a selective herbicide that controls Broadleaf Weeds, White Clover, Plantain, etc. Though non-selective herbicides are herbicides that damage any plant they come in contact with, such as the inorganic herbicide Glyphosate. Though, most organic herbicides tend to be non-selective contact herbicides (Kraehmer, 2014).

Each organic herbicide must contain at least a pre-emergent weed killer, which is primarily used in turf, such as Corn Gluten Meal; or, they must contain a post-emergent weed killer. Post-emergent weed killers include herbicidal soaps with fatty acids, highly concentrated acids, or essential oils. An example of three organic herbicides are Sodium Lauryl Sulfate, Acetic Acid, and Propionic Acid. Sodium Lauryl Sulfate is a herbicidal soap that is a non-selective contact herbicide. This herbicide works by stripping off the wax coating from the cell walls in leaves. This causes the leaves to lose water, and thus dehydrate. On the contrary, Acetic acid is a highly concentrated acid that is also a non-selective contact herbicide. This herbicide also causes cell walls to become damaged, and thus causing the plant to dehydrate. Lastly, Propionic acid is also a highly concentrated acid that is a non-selective contact herbicide. This herbicide reacts with the leaves, and thus completely damages the leaves all together. Additionally, Propionic acid is also mainly used to prevent mold in food or commercial items (Freidenreich, 2016).

Since more farmers have adopted the use of herbicides, there have been various research articles that have been conducted to examine the true effects of herbicides on the environment. A previous study was conducted regarding the effects of the exposure of inorganic herbicides such as Atrazine and Paraquat on the adult climbing ability and the longevity of *Drosophila melanogaster*. Previously, it was known for synthetic herbicides to cause oxidative damage, reduce longevity, and alter motor ability in non-target organisms. Therefore, for this research, different combinations of Atrazine and Paraquat were added to the control food in order to determine the impact on the climbing ability. It was concluded that Atrazine tended to reduce the climbing ability compared to Paraquat. Though, Paraquat had worse effects on female longevity compared to Atrazine exposure. Additionally, an observation was made that the amount of *Drosophila melanogaster* surviving decreased as the concentration of the Paraquat provided to the flies in their food increased. Therefore, both herbicides had an overall negative effect on the climbing ability and longevity of *Drosophila melanogaster* (Lovejoy, 2019).

Additionally, research has been conducted where the effects of herbicides on the herbivores of rice plants were tested. Firstly, the effect of the herbicides on the densities of the rice plants were tested because the density of the plants affected the number of organisms present that were feeding off of the plants. After this was conducted, the mortality rate of the rice plant herbivores were observed. It was concluded that direct exposure to the herbicide caused high mortality rates among the herbivores (Kraus, 2019).

Farmers have tended to switch to organic farming compared to inorganic farming. This has caused them to use organic fertilizers and herbicides, which are advertised as healthy and efficient. Though, it has not been known if they have similar effects on the environment as inorganic herbicides. If they were to be healthier than the inorganic herbicides, there would be minimal oxidative damage alteration motor ability in a non-target organism. Therefore, this research differs from previous research because organic herbicides, such as Sodium Lauryl Sulfate, Acetic acid, and Propionic acid, would be used instead of inorganic herbicides. Additionally, the method of exposure for each of the herbicides to the *Drosophila melanogaster* would be altered as well as the concentration of each of the herbicides. Not only this, the effect of the herbicides on the fertility rates of the females present will also be quantified in addition to the traditional climbing assay by counting the number of pupae stuck on the walls. The results from these different herbicides and respective concentrations would then be compared to the control group, which would contain no herbicide at all. Then, the overall results of this research would be analyzed, to determine the true effect of the organic herbicides on *Drosophila melanogaster.*

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