Lowest Lethality Dose (LDLO) of Various Seeds When Exposed to Detergent

David Hanan[1]

[1]North Shore Hebrew Academy High School

ABSTRACT

This study determines the lowest lethal dose (LDLO) of detergent on various seeds. Plants provide food and countless ecological benefits but oversight in wastewater release contaminates natural and agricultural vegetation. Due to widespread pollution, plant survival is in danger, making food scarcity and climate change imminent threats. Detergent is a common pollutant in the environment which greatly contributes to water pollution and harms plants. A useful index for environmental testing is the LDLO, the lowest lethality dose that will begin to inhibit growth. In this study, a representative selection of seeds, cabbage (*Brassica oleracea*), beets (*Beta vulgaris*), yellow bush bean (*Phaseolus vulgaris*), and turnips (*Brassica rapa subsp*) are exposed to various concentrations of detergent ranging from .5 mL to .1 mL in an attempt to find the LDLO of detergent of each species. Results showed that cabbage seeds had the highest tolerance to detergent at .25 ml of detergent diluted in .25ml of water and beet seeds had the lowest tolerance at <.025 mL of detergent. Visual observations showed that the outer layer of bush beans became an abnormal shade of black from its usual light-yellow hue. The results of this experiment reveal that cabbage seeds can tolerate higher doses of detergent as demonstrated by higher germination rates. The study suggests that cabbages can survive in areas exposed to higher concentrations of detergent. However, beets should not be planted in areas containing even small traces of detergent.

1. **Introduction**

1.1 Germination

Germination is the sprouting of seeds into plants after a period of dormancy. Germination will occur in a seed that has sufficient amounts of water, oxygen, light and the correct temperature. The amount of time a seed takes to germinate can vary based on its environmental conditions. Depending on the sensitivity of a seed to its environment, some seeds have the ability to germinate at a quicker rate than others. Before germinating, seeds conduct water imbibition which allows water to diffuse into the seed. In addition, proteins are synthesized, and food is stored within the seed in the forms of lipids and carbohydrates. (Awatif S. Ali and Alaaeldin A. Elozeiri. 2017). The germination of a seed is visible when the cells in the seed's radicle, the seed's protrusion which develops into the root of the plant, elongates from absorption of water causing the radicle to penetrate the endosperm of the seed. Once a seed germinates, the lipid and carbohydrates stored prior to germination are used to support plant growth (Bewley. 1997).

1.2 Detergent's impact on plants

Detergent is a common pollutant in the environment making it dangerous to plant life. High levels of heavy metals such as arsenic (As), cadmium (Cd), chromium (Cr), lead (Pb) and mercury (Hg) are all found in detergent (McGrath 1990). These heavy metals inhibit a seed's ability to conduct photosynthesis and hinders enzymatic activity. Surfactants in detergent which aid in trapping dirt when clothes are being washed, cause soil to become water-repellent when released into the environment, preventing seeds from getting water needed to germinate (Shafran. Ronen. Weisbrod. Adar. Gross. 2006). Detergent has a pH of 10 making it a basic mixture. When high quantities of detergent are released into the environment the pH of water increases, becoming basic. water absorbed by seeds results in an inhibited ability to conduct photosynthesis which damages the seed prior to germination to its adult stage (Christensen 2017).

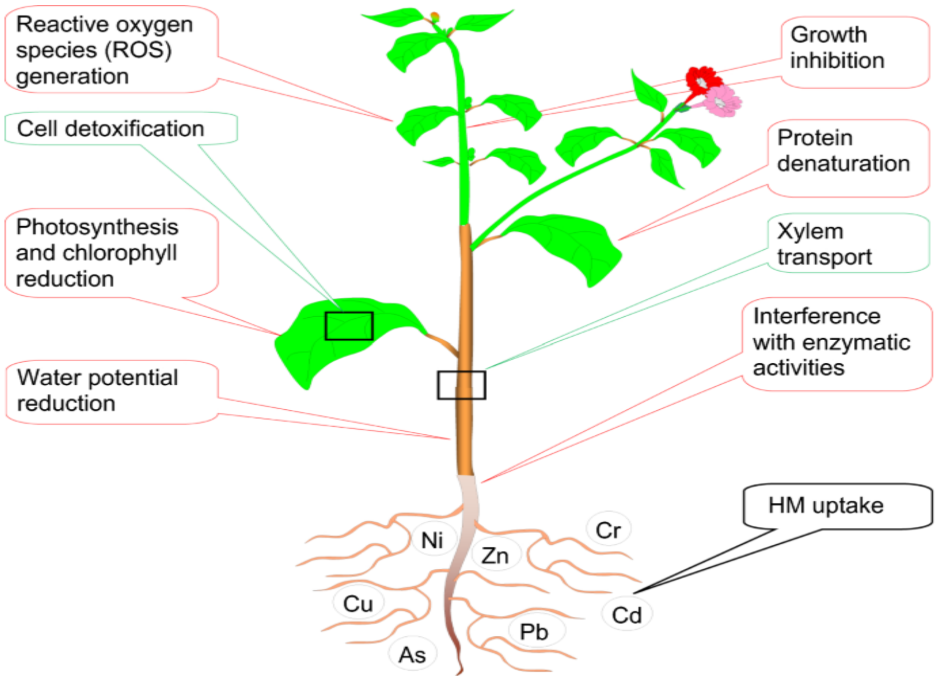


Figure 1: Absorption of Heavy Metals in Detergent. Heavy Metal uptake by seeds and plants from pollutants in the soil such as detergent hinder photosynthesis, growth and enzymatic activity which a seed requires to germinate and grow. (https://media.springernature.com/lw685/springer-static/image/art%3A10.1007%2Fs42452-021-04301-4/MediaObjects/42452_2021_4301_Fig1_HTML.png)

1.3 Effect of decreased plant life on the environment

A decrease in plant life due to liquid pollutants negatively affects the environment. Plants absorb carbon dioxide for photosynthesis. The decrease in plant life results in an increase in the amount of carbon dioxide in the atmosphere. The high level of atmospheric carbon dioxide speeds up climate change because it is a greenhouse gas which traps heat emitted by the sun and releases it back to the earth (Fecht. 2021). As a result, abnormal natural disasters such as heat waves, wildfires, tornadoes and hurricanes occur more often. The increase in climate change causes further decrease in plant life, resulting in an unhealthy feedback cycle. The higher temperature dries out seeds preventing germination. Plants would be forced to grow longer stalks and have smaller leaves in an attempt to cool themselves. The length of the stalks would leave the plant unsupported and unstable, eventually breaking (Marsh 2021).

1.4 Effect of decreased plant life on the economy

Agriculture is a major part of the United States economy. In 2019, the agriculture industry generated over a trillion dollars, 5.2 percent of the U.S. gross domestic product (GDP). As of 2020, 2.6 million jobs in the U.S. are direct on-farm employment. On-farm jobs, combined with all agricultural and food related industries add up to 19.7

million jobs, 10.3% of U.S. employment (Kassel. Martin. 2021). Agriculture is highly climate dependent, sensitive to sudden temperature and rainfall changes (Tun Oo. Van Huylenbroeck. Speelman. 2020). Harm to this sector would severely damage the economy. The probability of crop yield failures are projected to be 4.5 times higher by 2030 within many bread basket countries that are major producers of grains including the United States (Caparas. Zobel. Castanho. Schwalm. 2021). Crop failures will result in the loss of thousands of jobs and a sharp drop in the economy.

1.5 Purpose

The focus of this study was to find the lowest lethal dose (LDLO) of detergent to cabbage seeds (*Brassica oleracea*), beet seeds (*Beta vulgaris*), yellow bush bean seeds (*Phaseolus vulgaris*), and turnip seeds (*Brassica rapa subsp*). The lowest lethality dose (LDLO) is the amount of a substance that will begin to inhibit a population. Discovering detergent's LDLO to these seeds provides an understanding of which seed is most capable of growing in an environment with higher levels of pollution. Soil usage can be conducted efficiently as seeds which have a higher tolerance to pollutants such as detergent will be grown and have high germination rates in such areas. Pollutant sensitive seeds should not be grown in these areas as they will die out.

2. Hypothesis

Alternative Hypothesis (HA) **-** Detergent will have the highest LDLO to cabbage seeds and the lowest LDLO to turnip seeds.

Null Hypothesis (H0) - The germination of the various seeds will be unaffected by the detergent.

3. Materials and Methods

3.1 Plant Growth

Petri dishes were covered with two layers of filter paper. Ten seeds from a specific species were put into a petri dish for every experimental group and the control group as a representation of a population. Each dish received 10 grams of water via a pipette at the beginning of the experiment and none for the rest of the experiment. Seeds were grown at room temperature (22 °C) for 7 days.

3.2 Exposure to Detergent

Six experimental groups were created for each of the four types of seeds, each with a different concentration of detergent. Water was used as a diluent for the lower concentrations of detergent. Detergent and water were administered into each group via a micropipette. Group 1: 100% detergent (.5 ml). Group 2: 80% detergent (.4 ml) and 20% water (.1ml). Group 3: 60% detergent (.3 ml) and 40% water (.2 ml). Group 4: 50% detergent (.25 ml) and 50% water (.25 ml), Group 5: 40% detergent (.2 ml) and 60% water (.3 ml). Group 6: 20% detergent (.1 ml) and 80% water (.4 ml). In addition, a seventh control group was created.

3.3 Visual Observations

Visual observations such as abnormality in the color of each type of seed at different concentrations of detergent were recorded throughout the seven day period of germination.

3.4 Germination Rates

At the end of the seven-day germination period, the number of seeds that germinated in each petri dish were recorded.

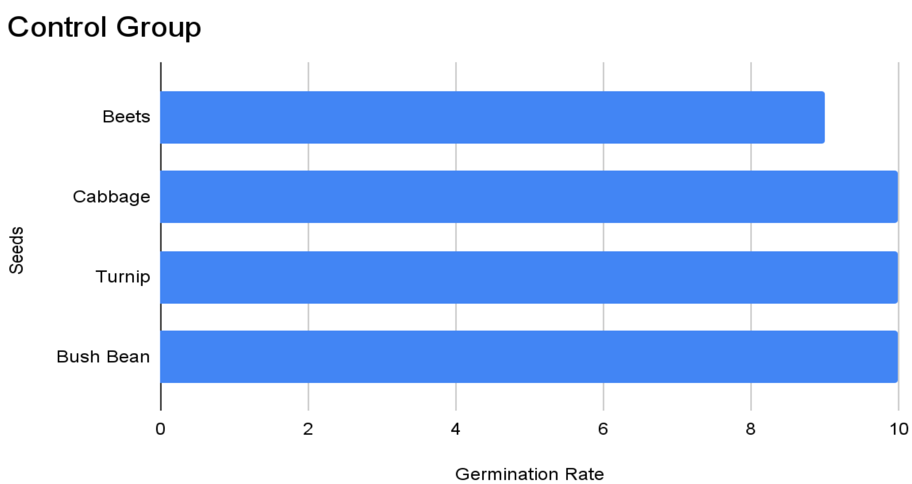
3.5 Further Experimentation of Beets

The LDLO of beets could not be found from the 7 original experimental groups. 3 additional petri dishes were made to find the lowest lethality rate of beet seeds. The amount of detergent administered in these petri dishes were .075 ml, .050 ml and .025 ml. After seven days the germination rates of the beet seeds in these additional experimental groups were recorded.

4. Results and Discussion

4.1 Control Groups Germination

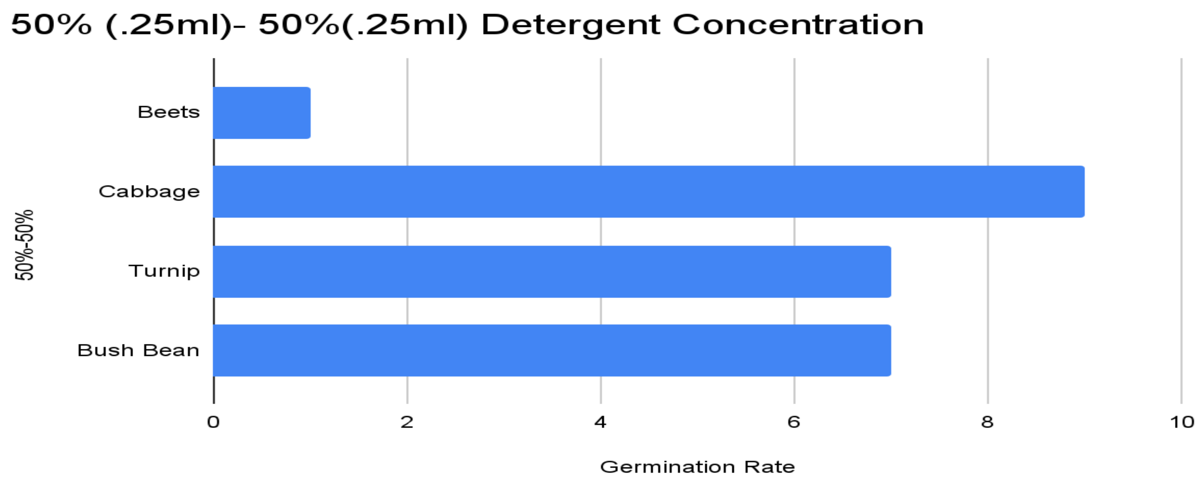
All the control groups had a 100% germination rate aside for the beet seed control which had a 90% germination rate.



Graph 1: Control Group Germination Rates. All seeds had a 100% germination rate aside for the beet seeds which had a 90% germination rate.

4.2 Cabbage Seed Germination

Cabbage seeds had the highest tolerance for detergent out of all the seeds. Detergent's lowest lethality dose to cabbage was a contraction of 50% detergent (.25 ml)-50 water%(.25ml). At 100% concentration of detergent (.5ml), cabbage had a higher germination rate than the other seeds at 50% while yellow bush bean and turnip seeds had a 10% germination rate and beet seeds had a 0% germination rate. The visual appearance of the cabbage seeds was normal - radicles were white and leaves had a light green hue, signifying a healthy germinated seed.



Graph 2: Germination rates of seeds to 50% detergent (.25ml) 50% water(.25ml) concentration. Cabbage seeds had a 90% germination rate, with only one seed out of the ten not germinating, elucidating detergent's LDLO on cabbage seeds at 50% detergent (.25ml) 50% water(.25ml).

4.3 Beet Seed Germination

Beet seeds had the lowest tolerance to detergent. When exposed to 100% concentration of detergent (.5ml) and 80% (.4ml) of detergent and (.1ml) of water beet seeds had a 0% germination rate. In all other experimental groups beet seeds had a 10% germination rate (one seed germinated). Further experimentation was conducted in an attempt to find detergent's lowest lethality dose to beet seeds. Additional experimental groups were created - .075ml, .05ml and .025ml of detergent within the 10 grams of water**.** Beet germination did occur at these lower concentrations, however only a 20% germination rate reached a contraction of .025 ml of detergent. Among the few beet seeds that did germinate, their leaves were shriveled and had brown colored patches signifying the severe damage caused by the detergent.

Figure 2: Petri dish of Beet seeds at a concentration of 20% detergent (.1ml) 80% water (.4ml). At the lowest contraction of detergent, beet seed germination was 10% as visible in Graph 2. The leaf of the single germinated beet seed is shriveled and has a brown hue, signifying the sensitivity of beet seeds to detergent.

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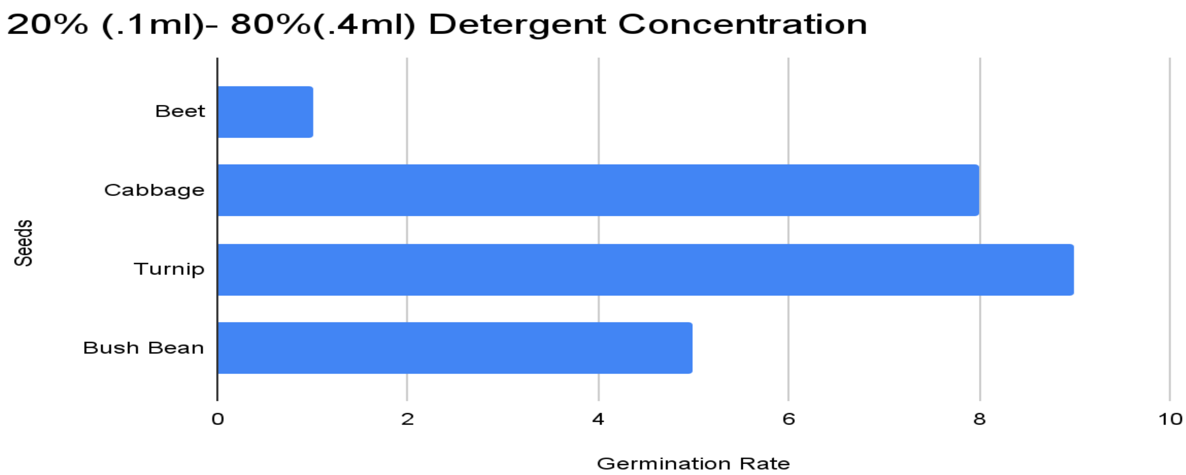

Graph 3: Germination rates of seeds at a concentration of 20% detergent (.1ml) 80% water (.4ml). All seeds had a distinctly higher germination rate when administered with 20% detergent (.1ml) 80% water (.4ml), having a 50% and higher germination rate, excluding beet seeds which had a 10% germination rate.

4.4 Turnip Seed Germination

Turnip seeds had a high tolerance to detergent. Detergent's lowest lethality dose to turnips was at the lowest concentration at 20% detergent (.1ml) and 80% water (.4ml). In comparison with cabbage, the turnip seeds were not as successful at germinating, although a recognizable tolerance to detergent was recorded. During germination, the turnip seeds did not develop any abnormalities in shape or color, retaining the light brown hue of their sprouts and dark green colored leaves. The turnips had a moderately healthy and successful germination.

Figure 3: Petri dish of turnip seeds at a concentration of 20% detergent (.1ml) 80% water (.4ml). At the lowest contraction of detergent, turnip seed germination was 90%. The visual appearance of the seeds shows that the seeds were healthy post germinating.

4.5 Yellow Bush Bean Seed Germination

Yellow bush bean seeds had a lower tolerance to detergent than cabbage and turnip seeds. Detergent's lowest lethality rate to yellow bush beans is >.1 ml of detergent diluted in .4 ml of water. At the lowest concentration of detergent at .1 ml of detergent diluted in .4 ml of water, yellow bush beans had a 50% germination rate, while cabbage and turnip seeds had 80% and 90% germination rates. The outer layer of the seed turned from a light-yellow hue to black and grew fuzz. In addition, the radicles of the yellow bush bean seeds developed brown patches.

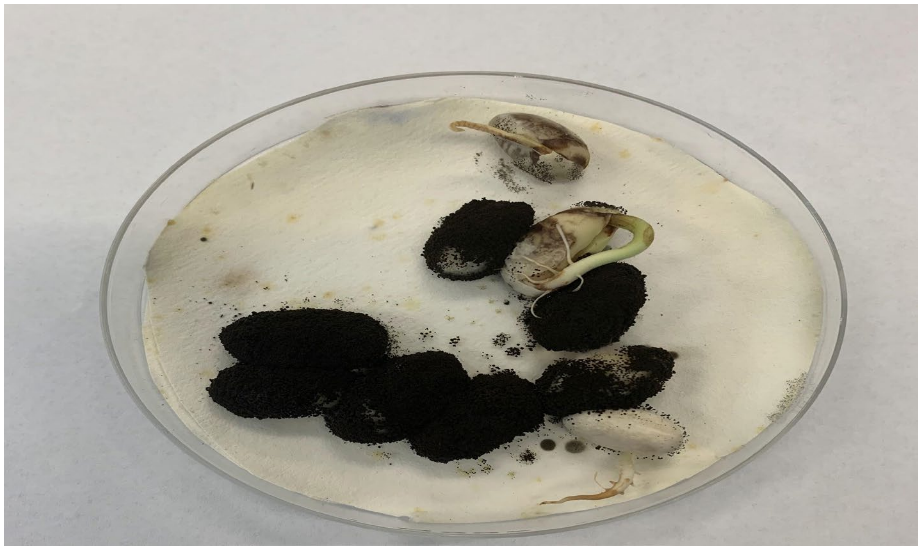

Figure 3: Yellow bush bean seeds administered with a concentration of 60% detergent (.3ml) 40% water (.2ml). The majority of yellow bush bean seeds are covered with black fuzz and brown patches formed on the radicles.

5. Conclusion and Future Work

This study partially supported the experimental hypothesis of detergent's lowest lethality dose (LDLO) to various seeds. Detergent's LDLO to cabbage was the highest out of all the other seeds as hypothesized, being 50% detergent (.25 ml) and 50% water (.25 ml). Cabbage seeds demonstrated the greatest tolerance to detergent out of all the seeds with germination rates in all experimental groups ranging from 50% - 100%. The seeds had a healthy germination, not developing any abnormal colors.

Beet seeds had the weakest tolerance to detergent which was not hypothesized. The highest germination rate recorded in all the experimental groups of beet seeds was 10%. Additional petri dishes with lower concentrations of detergent, ranging from .075 ml of detergent to .025 ml of detergent resulted in a maximum germination rate of 20% out of 10 beet seeds. The visual appearance of the few germinated beet seeds revealed shriveled sprout and abnormal color, signifying that although the seeds germinated, they were not heathy.

Turnip seeds had a high tolerance to detergent which proved the experimental hypothesis wrong. The LDLO of detergent to turnip seeds was 20% detergent (.1 ml) diluted in 80% water (.4 ml). Turnip seeds demonstrated germination rates close to cabbage seeds within all the experimental groups except the 100% concentration of detergent. Seeds had a healthy germination as observed from the sprouts having a dark shade of green and no other abnormal colors.

Yellow bush bean seeds were found to have a weak tolerance to detergent. Detergent's LDLO to yellow bush bean seeds was >.1 ml. In addition, seeds developed an abnormal coating of black fuzz on the outer layer. Seeds that did germinate developed brown patches on their radicles.

Future research on this study should investigate the reason why cabbage and turnip seeds had high germination rates when exposed to detergent. The development of black fuzz on the outer layer of yellow bush bean seeds should be investigated to determine metabolic processes that caused yellow bush bean seeds to develop visible abnormalities on their outer layer and radicles.

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