The Effects of Saline Soil on the Development of Fast Plants (*Brassica rapa)*

Abstract

The purpose of this experiment was to demonstrate how the level of salinity in the soil affects the development on a sample of plants. Initially, we hypothesized that a higher level of salinity would result in adverse effects on the development of the Fast Plants, *Brassica rapa*. Specifically plants treated with more saline soil would result in shorter plants with less alive leaves, less flowers, less seed pods, and lower germination rates when compared to a control group grown in non-saline soil. To test these hypotheses, we measured characteristics of two samples of fast plants. One of which, had a normal soil salinity, and the other which was treated with a higher level of salinity (1.5%). The data that we collected from our individual observations and the average class observations supports our hypotheses. Plants growing in a non-saline environment grew 30% higher than those growing in a saline environment. Additionally, non-saline grown plants had exhibited 23% more total leaf production 21 days after planting on average than those grown in saline soil. Plants growing in a higher saline environment showed significantly lower averages in pod yield, flower production and germination rates for both the parents and offspring. From this data we speculate that the cause of this difference in development is a result of salt-related stresses caused by the plants growing in the saline soil environment.

Introduction

We did this experiment to see if the salinity level of soil will affect the overall growth of a plant. According to the U.S. Department of agriculture, typically, high salinity levels hinder a plant's ability to grow, as turgor pressure decreases due to solutes surrounding the plant pull water away

from it (Ogle, 2010). High salt levels in the soil can cause entire crops to die of dehydration, while some ions are toxic to plants (Munns, 2008). Some plants are better

adapted to changing to their environment where salt levels may vary (Paridas and Das, 2004).The salt in the soil does not only affect the plants grown in the saline soil, but also the survivability of future generations. As the world population continues to grow, the demand for agricultural fertile land will also increase. In order to accommodate this growing population, we will need to be able to take advantage of every acre of land we can use; this includes the more saline soils. It is estimated that about 20% of cultivated land is saline, with even higher percentage in irrigated areas (Shrivastava and Kumar, 2014). If the foods grown in these soils affect the development of the plants grown there then that is a huge opportunity loss for humanity. As a result, we are conducting this experiment to test the claims stated above of whether saline soil has adverse affects on the development of plants. We hypothesize that the plants grown in saline soil will have lower germination rates, grow less tall, and have less leaves, flowers, pods than the control group grown under normal conditions.

Materials and Method

Each person made a control and a experimental quad. The quads were made by inserting a wick into the bottom hole of a prepared styrofoam cube with 4 sections. The control quads were filled with ordinary soil and the experimental quads were filled with 1.5% saline soil. The quads were filled halfway up, then a fertilizer pellet was placed in each section. The quads were then filled to almost the top, and then seed was placed in each section before completely filling it. Water was applied to the soil until it dripped out of the bottom. The quads were placed on top of reservoirs in the greenhouse. The reservoirs were plastic buckets with regular tap water inside. The water

was the same between treatment and control, as the salinity was in the soil. A cotton sheet was draped across the lid of the bucket, dipping into the water on both sides. Water traveled through the cotton and was absorbed into the soil through the wicks. The greenhouse was lit at all times throughout the course of the experiment. When the seeds began to germinate we recorded the percentage of seeds that had germinated. If there were quads were both seeds had not germinated then we would transplant a plant from a quad that had multiple growing into the empty quad. Once the plants have been established we would cut the stem of the shortest plant if there were multiple ones growing in the same quad so that there was a maximum of one plant per quad.

To produce seeds for the offspring generation we pollinated the flowers once they appeared on 9/13/16 and again on 9/15/16. We pollinated flowers using brushes. We brushed the flowers of one plant to collect pollen and then brushed the plant of a different plant to transfer the pollen. Pollen was transferred between plants until all flowers had received pollen from a different plant. We pollinated twice to ensure success and to pollinate any new flowers. After the second pollination date we removed any new flowers to make the plants devote their resources into making pods instead of flowers. Pollen was only transferred between plants of the same group, salt treatment or control. If someone did not have enough plants in a group to pollinate with only their own plants, pollen was taken from another person's plant of the same treatment group. Different brushes were used for the different groups to ensure only pollen from one group could pollinate the plants in that group.

On 10/6/16 we harvested the seeds from the pods and planted them to find the offspring germination percentage. To harvest the seeds we removed pods from all of our plants and placed

them into separate piles for the salt treatment and control group. The pods were then cracked open by hand and the seeds were placed in petri dishes. Two other petri dishes were prepared with filter paper that had been moistened with tap water. From each collection of seeds we selected 25 seeds. We placed the 25 seeds into their respective petri dishes. The seeds were spaced out to prevent crowding from hindering germination. We discarded the leftover seeds. The petri dishes were stored for 5 days to allow time for germination. On 10/11/16 we looked for germination in the offspring.

The entire class measured the percent of plants in the parent and offspring group that germinated, the heights of each plant, and the number of flowers. Our group decided to measure the number of alive leaves. We also counted the number of pods on each plant. The percent germination of the parent generation was measured the first three lab periods after planting starting on 8/29/16 and ending on 9/6/16. The percent germination of the offspring generation was measured once on 10/11/16, five days after planting the seeds. The height of the plant and number of leaves were measured every Tuesday and Thursday during lab starting on 9/1/16 and ending 9/22/16 when we stopped watering

them to prepare for seed harvesting. We counted the number of flowers once they first appeared and the next lab period, on 9/13/16 and 9/15/16. The number of pods were counted on the day we harvested them, 10/6/16. We measured height from the soil level to the apex of the stem. Leaves were considered dead when half of the leaf wilted and no longer green.

Results

Class Results. The class average percent germination (Figure 1) was calculated by taking the percent germination of two seeds from each of four quads for twenty-five students for both the treatment and the control group. In general, the control group exhibited a higher germination rate then the treatment group. The control group also had a smaller standard of deviation than the treatment group. The class average plant height (Figure 2) were measured by using rulers to measure how many centimeters in length the plant was from the soil level to the apex of the stem. Both treatment and control groups showed logistic growth where the control group seems to reach their height limit at around 25 cm while the treatment group evened out at around 17.5 cm. For the class average number of flowers (Figure 3) we counted the number of flowers and define that we would count the flower if it had opened. If the flower bud hadn't opened yet it would not count. The control group, in general, had more flowers than the treatment group. The control group also had a smaller standard of deviation. The class average offspring germination (Figure 4) was calculated by collecting a larger number of seeds from each of the group's combined control plants and combined treatment plants (keeping the control seeds and the treatment seeds separate). Then randomly selecting 25 seeds from the control group and 25 seeds from the treatment group and letting them germinate in a damp petri dish. The combined data from 6 different lab groups were compiled to form the class averages. Overall the control group had a higher germination percentage than the treatment group. The treatment group, however, had a smaller standard of deviation than the control group.

Group Results. For our group average alive leaf number (Figure 5) we defined a leaf as being alive if more than 50% of the leaf is green and still functional for photosynthesis. The control group reached a higher maximum with an apex of 5.19 leaves at day 21 while the treatment

group reach their maximum of 4.00 leaves on day 21 and 23. The control group then begins to decline significantly after day 21 however the treatment plants only exhibit a slight reduction in average leaves after day 23. In general, the control group had smaller standards of deviation than the treatment group. For the group average number of pods (Figure 6) we defined a pod as having at least one fully developed seed. The control group had more pods with an average of 5.00 pods while the treatment group had a smaller average of 2.88 pods. However, the treatment group exhibited a smaller standard of deviation than the control group.

Discussion and Conclusion

Across all the variables, the salt treatment group did not perform as well as the control group. As hypothesized, the treatment plants had lower germination rates for both the parent and the offspring generation, they produced less flowers, leaves, and pods, and did not grow as tall as the control plants on average. Not only did the treatment plants grow less they also started growing later than the control plants. The germination for the parent generation was recorded three times. While the control group was only slight increases each time they were measured, the treatment group had a large jump from the first day's measurement to the other two times. This indicates that the salinity slowed the germination rate. Similarly, the difference between the first and second measurements for flower number is much greater in the treatment group than the control group. This shows that the control plants were further along in their development of reproductive organs than the treatment plants when we measured the flower count. For our group trait of number of alive leaves, the trend was similar to the others, with the control having more throughout the measurement period; however the control group lowered to the level of the treatment by the last day of measuring. This was after pollination and likely due to the plant

diverting the resources from the leaves to the pods. The results we had agree with the information from both Munns and Tester (2008) and Parida and Das (2005), which showed plants would develop smaller shoots and smaller and fewer leaves in saline soil. The osmotic difference in saline soil would disrupt the development of new leaves, which explains the lower leaf number of our treatment plants. The osmotic change due to salt stress also hinders elongation of cells during growth, leading to the shorter shoots of the treatment plants. Not only were the plants smaller, with fewer leaves and lower germination percentages, but the reproductive traits were also negatively impacted. The treatment plants had fewer flowers to be pollinated, leading to fewer pods. The percent germination of the offspring was also lower, showing the seeds produced by the treatment plants were less viable. The saline soil affects not only the plants grown in the saline soil, but also the survivability of future generations, regardless of the environment available to them. As the world population continues to grow, the need for agricultural land will also grow. To provide enough food we will need to use more saline soils. Currently it is estimated that 20% of cultivated land is saline, with a higher percentage in irrigated area; these numbers are only expected to grow in the future (Shrivastava and Kumar 2014). The results of our experiment indicate that saline environments will impede the growth and reproductive success of crops in these regions. This would cause a reduction in efficiency of agriculture for plants grown in saline soil and plants grown from the seeds of those plants. However, our experiment only examines one species of plant which was chosen for its short lifecycle. Munns and Tester (2008) note that plants have varied tolerances to salt stress. Some plants have adaptation to perform better in saline soils. As our experiment only looks at a single species, it may not apply to all important crops. To test this we would conduct the same type of experiment with a variety of different plants to see how they respond to saline soil.

Works Cited

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Summary Tables for CLASS data

Plant Height (cm)

Treatment Control

Date 8/25 Day 0 Ave 0 SD 0 Ave 0 SD 0

8/29 9/1 5 7
0 1.3 0 1

0 2.9 0 0.9

9/6 9/8 12 14 3.4 6.2 2.9 4.8 9.9 14.8 3 4.2

9/13 9/15 19 21 13.1 15.6 8.5 8.4 21.8 24.2 5.6 6.2

9/20 9/22 26 28 17.2 17.4 8.1 8.1 24.9 25.1 6.7 6.8

% Germination - Parents

Date 8/29 9/1 9/6 Day 5 7 12

Treatment Ave
SD 45.4 41.7 41.2

Control Ave
SD 28.7 27 23.9

# of Flowers

Date 9/13 9/15 Day 19 21

Treatment Ave
SD 3.53 4.64

Control Ave
SD 3 3.5

% Germination - Offspring

% Germination Treatment Ave 28

SD 14.3 Control Ave 42

SD 16.5

48 63.8 64.3

85.5 89.3 90.5

3.13 5.42

7.2 8

Appendix

Summary Tables for GROUP Data

# of Alive Leaves Date Day

8/25 9/1 0 7
0 0.89 0 0.6 0.00 1.88 0.00 0.34

9/6 9/8 12 14 2.22 2.56 1.2 1.42 3.38 4.44 0.81 0.96

9/13 9/15 19 21 3.44 4 1.59 1.8 5.13 5.19 1.02 1.17

9/20 9/22 23 28
4 3.89 1.87 1.83 4.56 3.81 1.31 0.83

Treatment Control

# of Pods

Treatment Control

Average SD Average SD

Date 10/6

Day 42 Average 2.88 SD 1.55

Average 5 SD 2.07

Raw Data Tables
VARIABLE: Leaf Number (ALIVE)

CONTROL

Name Plant# Alex1

2 3 4

Matt1 2 3 4 Emil1 2 3 4 Brady1 2 3 4

Average SD

Date Day

8/25 9/1 07

9/6 9/8 12 14

9/13 9/15 19 21

9/20 9/22 23 28

02456544 02234443 02455533 02344433 02235555 01445554 02444433 02456665
02345544 02445444 02445543 02244445 02455644 02478873 02356773 01355665
0.00 1.88 3.38 4.44 5.13 5.19 4.56 3.81 0.00 0.34 0.81 0.96 1.02 1.17 1.31 0.83

NOTE: X= dead plant.

VARIABLE: Leaf Number (ALIVE)

TREATMENT

Name Plant# Alex1

2 3 4

Matt1 2 3 4 Emil1 2 3 4 Brady1 2 3 4

Average SD

Date Day

8/25 9/1 9/6 9/8 9/13 9/15 9/20 9/22 0 7 12 14 19 21 26 28

01345554 01225533 01244666 01323333 00113566 XXXXXXXX 01445555 00000000 XXXXXXXX 01233444 02333344 XXXXXXXX 0XXXXXXX 0XXXXXXX 0XXXXXXX 0XXXXXXX 0.00 0.89 2.22 2.56 3.44 4.00 4.00 3.89 0.00 0.60 1.20 1.42 1.59 1.80 1.87 1.83

NOTE: X= dead plant.

VARIABLE: Pod Number CONTROL Date 10/6

Day 42

5 27 36 46 Matt 1 2 23 37 46 Emil 1 5 27 38 45 Brady 1 0 24 34 45

Average 5.00 SD 2.07

VARIABLE: Pod Number TREATMENT Date 10/6

Day 42

3 24 34 44 Matt 1 0

2X 31 4X

Emil 1 X 24 33

4X Brady 1 X 2X 3X 4X

Average 2.88 SD 1.55

NOTE: X= dead plant.