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# GROWTH AND SUCCESS OF COMMON AGRICULTURAL CROPS IRRIGATED WITH WATER OF DIFFERING ACID MINE DRAINAGE IMPACT

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## ABSTRACT

A major source of industry in Pennsylvania is mining of the land's natural coal deposits, particularly through a practice called surface mining. This process produces land which cannot easily be used for agriculture, and water which flows through these mined areas becomes acidified and saturated with heavy metals. Although the health concerns related to AMD have become common knowledge, little research has been done on the effects of farmland irrigation with this impacted water. The agricultural repercussions of mine drainage were investigated through collection of data on germination success, average plant height, and groundcover ability of a common Pennsylvania crop, alfalfa. Water from both pre-limestone treatment and post-limestone treatment which was contaminated by drainage was used to irrigate small plots of alfalfa seeds. No statistically significant observations were found between the treatments, but interesting trends observed in growth rate and height warrant further investigation.

*Keywords: AMD, Agriculture, Irrigation, Medicago sativa, Pollution*

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## INTRODUCTION

Corn (*Zea mays*) ("Sweet Corn - Department of Horticulture and Landscape Architecture" n.d.), snap bean (*Phaseolus vulgaris*) (Bitocchi et al. 2012), and alfalfa (*Medicago sativa*) (Sullivan 2020), are widely distributed food and animal feed products of Pennsylvania, with 1,105,200 acres harvested in 2019 ("USDA/NASS 2019 State Agriculture Overview for Pennsylvania" 2020). These crops are a very important part of PA's economic and ecological biodiversity, providing food and cover for not just domestic animals but also local wildlife.

Another major source of industry in Pennsylvania are our vast coal deposits, resulting in 287,000 acres of land cleared within the state (Dutta et al. 2016) for surface mining (also known as "strip" mining) operations. Unfortunately, not only is the land unable to be repurposed without major

revitalization for agricultural purposes, but runoff from mined areas has been shown to reach very low pH values, below the point of corrosivity to metal. That being said, Broadtop Pennsylvania has taken matters into its own hands, and has become a test sight of many AMD stream recovery efforts, including the relatively low-maintenance limestone passive treatment system, which has been shown to revitalise streams and raise pH values back to acceptable ranges for agriculture and human consumption.

The objective of this study is to provide specific information on success of corn, bean, and alfalfa seedlings grown with water which has been impacted by mining operations, with a secondary aim to assess the success of limestone treatment ponds from an agricultural perspective. The design of the experiment separates all seeds into separate plots to be watered with water collected from one of three

## DOI

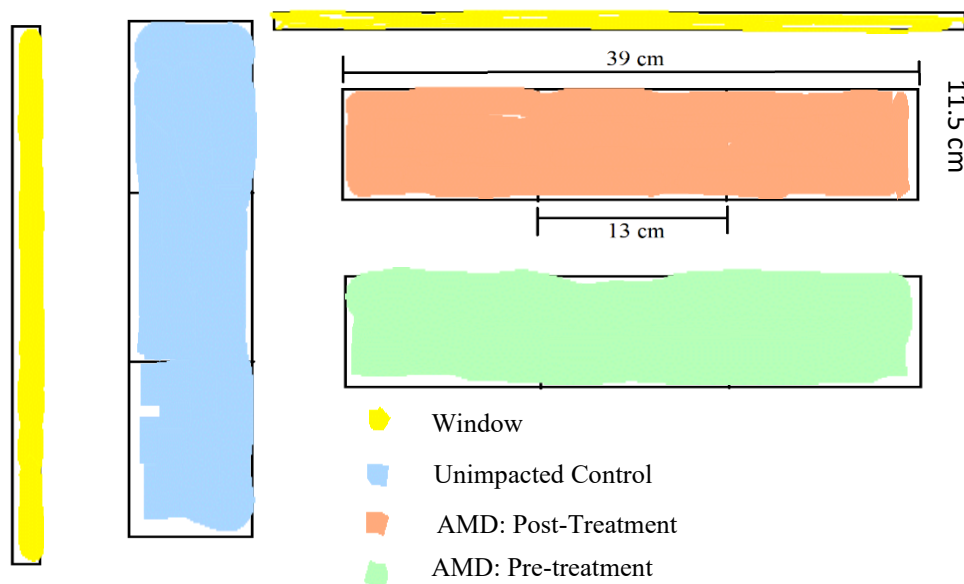
sources: AMD impacted water, AMD impacted water that has gone through limestone treatment, and water from a stream unimpacted by AMD to serve as a control.

The main concern is that the weather will be too cold, causing all of the plots to fail to germinate. To avoid this, the crops were covered on nights where it will fall to temperatures near freezing with a thin plastic cover with holes in it to shelter from harsh conditions and have left the planters on the semi-enclosed back porch.

## METHODS

Corn, bean, and alfalfa seeds were sown on 4/12/2020 in three planters to separate each from contamination of differently impacted water. One packet each variety of seeds was split evenly between three different containers. Each container will receive water every other day from one of three sources: stream water which is considered healthy and uncontaminated, stream water which has been impacted by AMD, and a sample which has undergone passive AMD treatment (See figure 1). A total of 60 corn seeds, approximately 690 alfalfa seeds, and 45 bean seeds were planted per container.

Figure 1: Sketch of Setup



Due to the overall lack of successful sprouts of beans and corn -with a total of 1 bean growing (in AMD post-treatment) and 2 total corn sprouts (in uncontaminated control and post-treatment)- these species were discarded in analysis, leaving only alfalfa for statistical exploration.

Data for alfalfa was collected for each plot in three categories: seedling germination success (total individuals observed), average height of individuals (cm), and ground cover percentage. Growth was determined based on successful germination of seedlings and plant growth in cm, as well as observational data regarding coloration and other physiological differences between individuals. Data collection took place over a span of 20 days, sampling every two to four days. Ground cover was estimated using methods described by the *Australian*

*Government National Landcare Program* (2018) for the full plot of alfalfa. PH was determined at time of water collection using pH strips.

## RESULTS

### PH

None of the pH values of the water samples fell within optimal ranges, but the untreated AMD water. Because of my relatively limited supplies the only water quality measurement I was able to obtain for the three sources was pH via test strips. All of the values were found to be below the recommended 6.5 minimum pH for drinking water (Swistock et al. 2008), with untreated AMD water having a pH of

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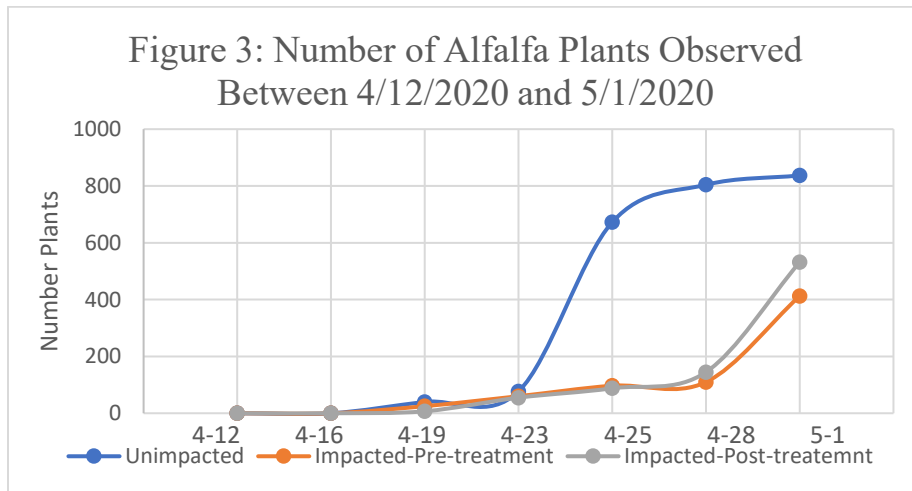
5.2, treated AMD water having a pH of 5.8, and the unimpacted control with a pH of 6.2 (see figure 2).

Figure 2: pH Values

|           | Untreated AMD Water | Treated AMD Water (limestone) | Unimpacted Water |
|-----------|---------------------|-------------------------------|------------------|
| pH Values | 5.2                 | 5.8                           | 6.2              |

**Germination Success**

Because of the high quantity and density of growth in alfalfa I used random quadrat methods similar to those described by Uetz and Unzicker, but with much smaller sampling sizes (1 cm x 1 cm) and a random number generator to randomly select 10 quadrats. The mean of these values was calculated to determine the average number of individuals per cm<sup>2</sup>, then multiplied by the plot size (149.5 cm<sup>2</sup>) for a final amount of alfalfa on each day (see figure 3).



Total alfalfa observed on each observation day of the 20 day experimentation window are shown on the graph for each of experimental plots. The unimpacted plot is shown with a blue line, while blue represents the impacted post-treatment plot and orange represents the impacted pre-treatment plot.

The highest germination success rate as of day 20 of the experiment (5-1) was 93%, with 837 of the 900 total seeds successfully germinating. The impacted subgroups from before and after AMD treatment were distinguished by a much lower success rate of 45% and 59% for pre-limestone treatment and post-limestone treatment respectively.

**Height**

Average height was also computed on every observation day to isolate the effects of different water on overall plant height. No significant correlation (P = 0.44) was found between AMD treatments, but a more significant variation was seen between the samples and unimpacted control (p= 0.12) (see figure 3).

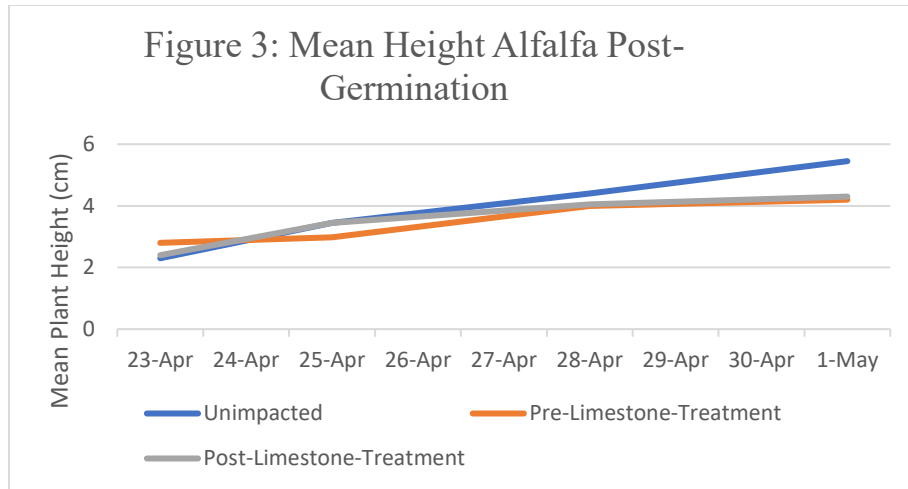


Figure 3: Mean alfalfa plant heights starting on day of first observed growth (4/23) through final day of experimentation (5/1).

**Groundcover Percentages**

Total groundcover percentage was estimated and recorded for each plot over the course of the

growing period. The maximum groundcover was 68% (unimpacted control) followed by 50% (pre-treatment AMD) and 42% (post-treatment AMD) (see figure 4).

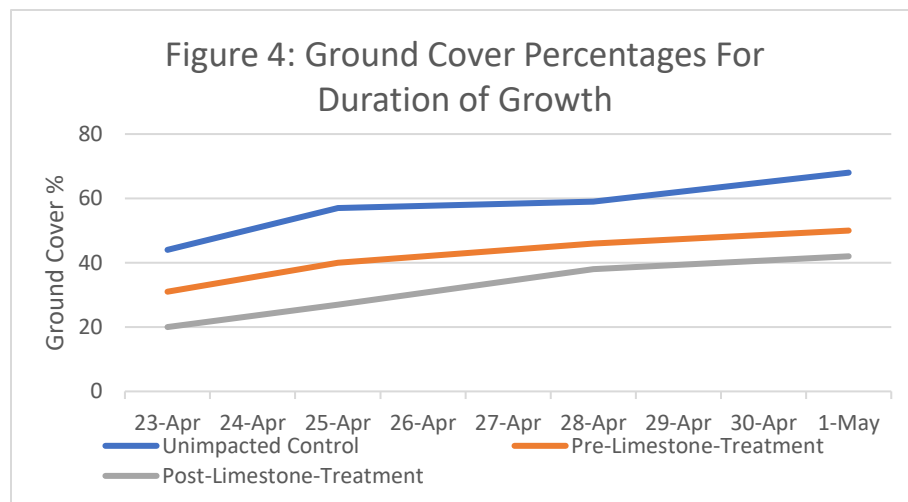


Figure 4: Chart of estimated ground cover percentages of alfalfa, starting on day of first observation (4/23) and ending on the final day of experimentation (5/1)

**DISCUSSION**

The success of using the three different waters to irrigate the soil of plants in this experiment was determined by three factors: germination success, height of the plants, and percentage of the earth that was covered for each of the three treatments. The group that was the most successful in each of these categories was the unimpacted control

water, with successful germination at 93% of individuals and, interestingly, these seeds reached their peak sprouting rate a full 6 days before either of the AMD impacted sites. A more subtle difference was seen between the pre and post limestone treatment samples and germination success (48% and 59%), it is reasonable to assume that there is minimal or no effect of this treatment on the germination success of alfalfa. Even more slight differences were

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seen between the AMD test plots when considering average plant height, although the unimpacted plants were an average of over 1 cm taller at the end of the testing window. Ground cover percentages showed no significant trends.

A major limitation in this study were the lack of growth of corn and bean plants. This could have been due to weather and climactic concerns, with temperatures unexpectedly falling to near 4.5° C. This left only alfalfa to serve as an indicator of water quality impact on success rate of crop growth.

Future experimentation may be more successful more controlled environment for the growth to limit temperature concerns, as well as more water quality measurements to eliminate confounding variables. Further studies should also consider pods with individual seeds in each to quantitatively assess the success of germination without estimation and determine death rates of each population.

## ACKNOWLEDGEMENTS

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