

# **THE EFFECTS OF NITRIC ACID ON THE SHOOT LENGTH, ROOT LENGTH, AND DRY MASS OF THE SHOOT OF RADISH PLANTS**

Jessica Tarr, Michael McPeak, Cameron Miller, Jamie Prior

## **INTRODUCTION**

Acid deposition, also known as acid rain in its wet form, can harm forests and crops by leaching essential plant nutrients from soils. Acid rain is the process whereby pollutants such as nitric and sulfuric acids are spread over wide areas by the prevailing winds and then fall to earth with the precipitation (Raven 1988, Figure 1). The major effect of acid rain is the result of the acidity of the soil in which the plant is located—the lower the pH, the more acidic the soil. (Barnhart 1986).

Soil pH is affected by the nitrogen in acid rain. Plants can grow in soils in a pH range of 3 to 9. Some plants grow in more acidic soil while some grow in more alkaline soil. Acidic soil, like that found after acid rain has fallen, may limit plant growth simply because  $H^+$ , the acidic part of a molecule, is toxic to roots (Salisbury and Ross 1978).

Along with the effects of pH on soil, pH also affects the plant's semipermeable membrane, allowing particles to travel through the cell membranes more easily. This affects how well plants are able to absorb nutrients and how well they can keep toxins out (Considine 2002). Acid deposition rarely kills plants directly but can weaken them and make them more susceptible to other stresses such as severe cold, diseases, insect attacks, drought, and harmful mosses (Miller 2005).

Nitric acid, one component of acid deposition, travels through the air as gaseous nitrogen, making up 80 percent of the lower atmosphere. Plants rely on the nitrate ion ( $NO_3^-$ ) because it and the ammonium ion ( $NH_4^+$ ) are the easiest ions for plants to absorb

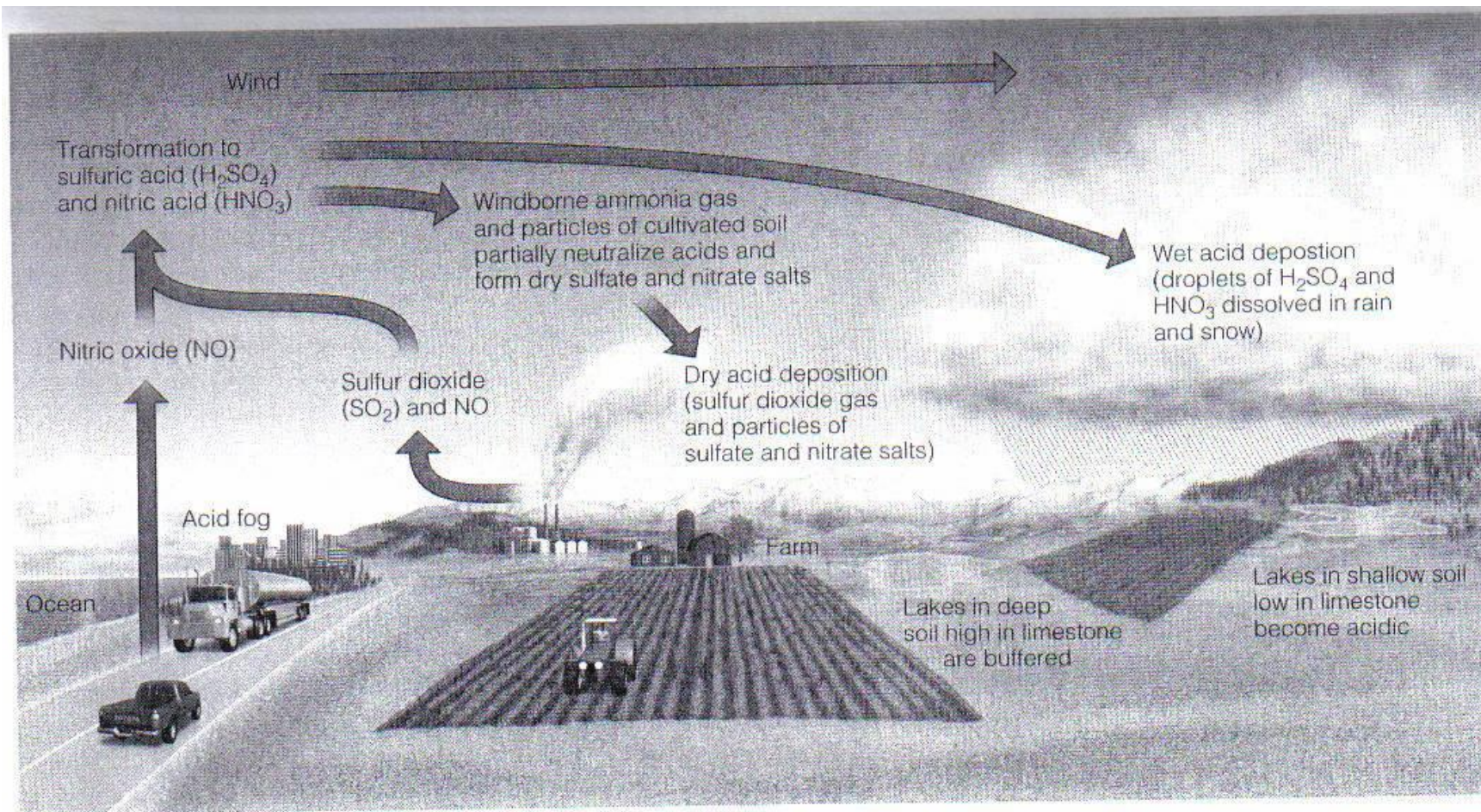


Figure 1. Acid deposition cycle (Miller Jr. 2005).

(Considine 2002). As was stated before, nitrogen and all of its counterparts ( $N_2$ ,  $NO_2$ , etc) can help and/or inhibit plant growth.

The use of nitrogen fertilizers adds hydrogen ions to the soil, making it more acidic (Starr 2006). These ions can displace other positively-charged mineral ions, such as magnesium and calcium, from binding sites on soil particles. Nitric acid ( $HNO_3$ ) affects soil because of its nitrogen atoms. In small concentrations, it can be beneficial to most plants as a fertilizer, combining with other elements to form nitrates (Considine 2002).

The acidity of the soil influences the physical properties of the soil, the availability of certain minerals to plants, and the biological activity of the soil. It consequently strongly influences plant growth (Weier 1974). Too much or too little light can affect the growth of the plant (Lambers and Chapin 1998). The amount of water the plants will be receiving is crucial to their growth. Approximately 95 percent of a plant is made out of water (Weier 1974).

The purpose of this paper is to discuss the effects of nitric acid on the shoot length, root length, and dry mass of the shoot of radish plants. We will determine whether or not the pH of the nitric acid affects the growth of the plant by applying nitric acid solutions of pH 4, 5, and 6 and measuring the shoot length, root length, and dry mass of the shoot of the radishes.

## **METHODS**

Each pot was filled with soil until the soil was 2.5 cm from the top. The soil was compacted. The soil was pretreated with Miracle-Gro fertilizer. Three groups of 24

radish seeds were counted out and separated. Each group of seeds was then soaked for 24 hours before planting in petri dishes of the correlating pH with enough nitric acid to cover the seeds. Two seeds were planted in each pot. More of the same soil was then added to each pot so that the soil measured 1.3 cm below the top of the pot, making sure the soil was still compact.

The plants were grown under three 34 watt fluorescent lights that were suspended 20 cm above the flats. These lights stayed on for 24 hours a day for 12 days. The flats were positioned so that each flat received the same amount of light. The flats were watered on an as needed basis in order to keep the soil moist. One of the flats was watered with the nitric acid solution of pH 6. The second flat was watered with the nitric acid solution of pH5. The third flat was watered with the nitric acid solution of pH 4.

After growing the radishes for twelve days, the plants were unearthed and cleaned, using a stream of tap water. The shoot length of every plant and the root length of every plant were measured to the nearest 0.1 cm. After measuring, the roots of the plants were cut off with a razor blade. Then, all the plants were placed in a dehydrator at 49°C for 24 hours. After the plants were dehydrated, they were weighed to the nearest 0.0001 g.

The resulting data was put in to an Excel data sheet. Using the ANOVA test, tables were made using Analyse-It.

H<sub>0</sub>: Nitric acid has no effect on the shoot length of radish plants.

$$\mu_{SL6}=\mu_{SL5}=\mu_{SL4}$$

H<sub>a</sub>: At least two of the means vary.

H<sub>0</sub>: Nitric acid has no effect on the root length of radish plants.

$$\mu_{RL6}=\mu_{RL5}=\mu_{RL4}$$

H<sub>a</sub>: At least two of the means vary.

H<sub>0</sub>: Nitric acid has no effect on the dry mass of the shoot of the radish plants.

$$\mu_{DM6} = \mu_{DM5} = \mu_{DM4}$$

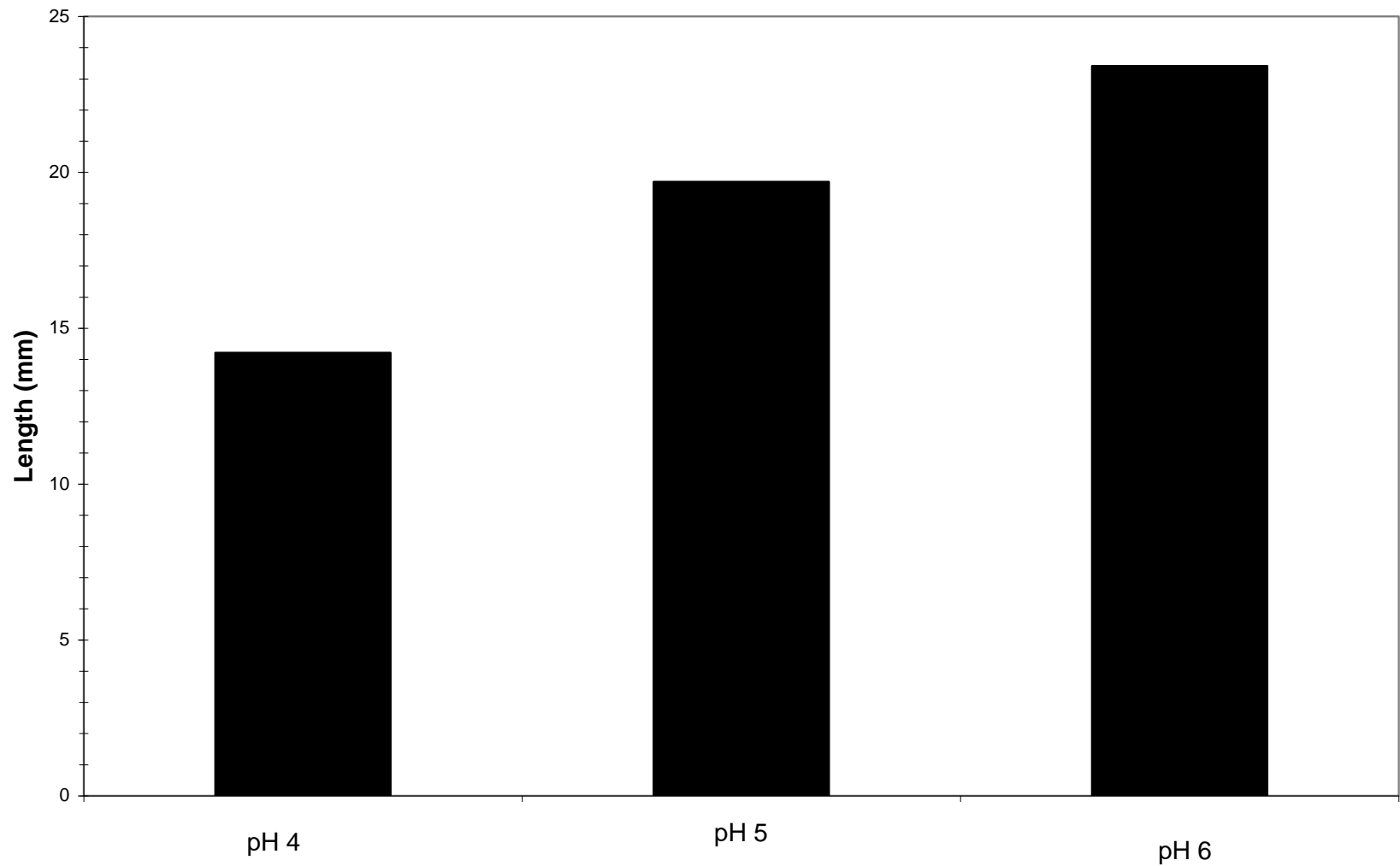
H<sub>a</sub>: At least two of the means vary.

## RESULTS

Figure 2 shows our mean shoot lengths of 14mm for pH 4, 20mm for pH 5, and 23mm for pH 6. The ANOVA test resulted in  $F=6.88$  and  $p=0.0021$  (Table 1). The difference between the mean shoot length of the radish plants grown in pH 4 versus the mean shoot length of the radish plants grown in pH 6 was significant, determined by the ANOVA test. Therefore, we rejected the null hypothesis that nitric acid has no effect on the radish shoot length and proved the alternative hypothesis that nitric acid has an effect on radish shoot length.

Figure 3 shows our mean root lengths of 35mm for pH 4, 50mm for pH 5, and 44mm for pH 6. The ANOVA test resulted in  $F=1.77$  and  $p=0.1800$  (Table 2). The difference between the root lengths of radish plants grown in the different pH levels was not significant. Therefore, we failed to reject the null hypothesis. We concluded that the pH of nitric acid did not significantly affect the mean root length of radish plants.

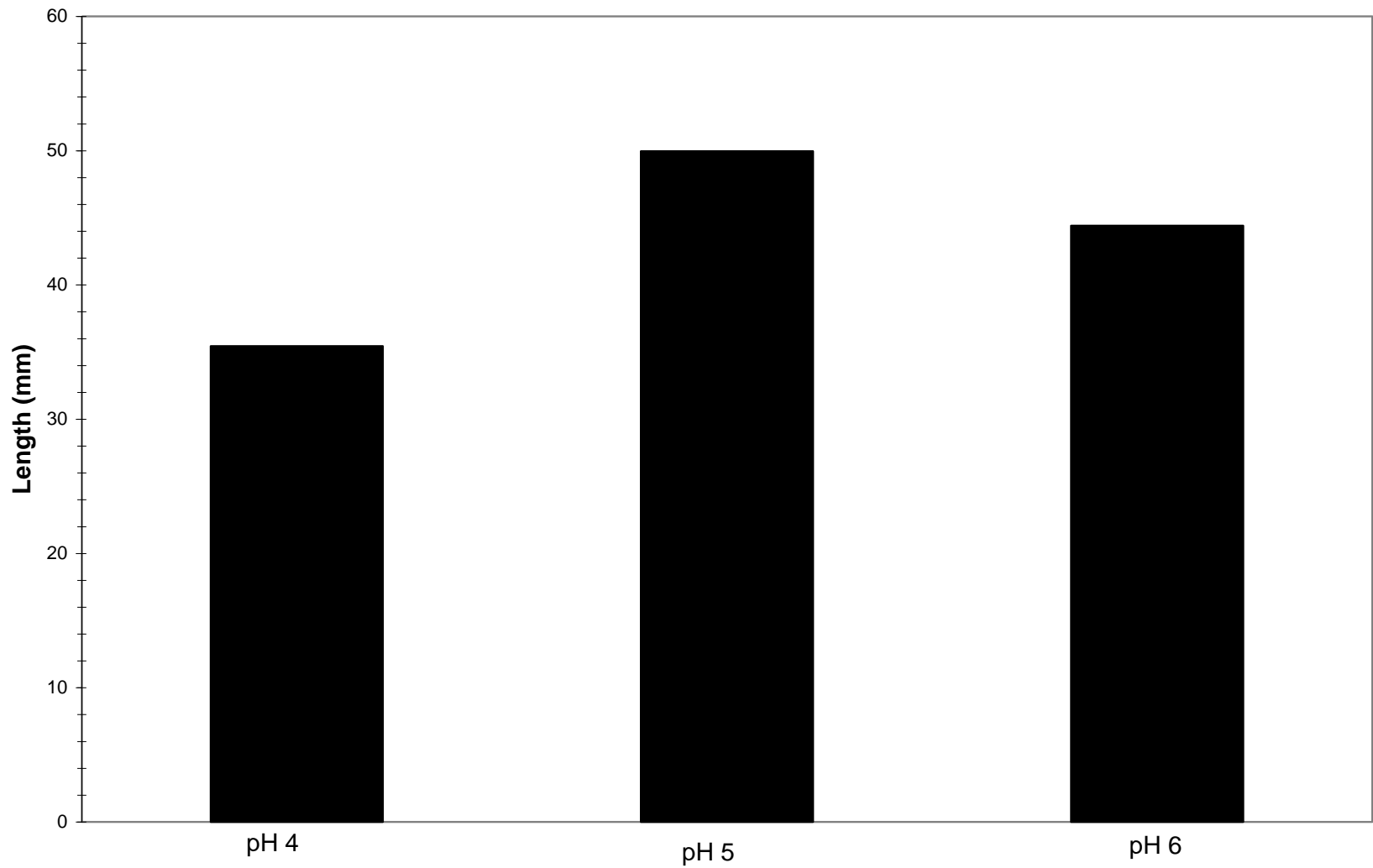
Figure 4 shows the dry shoot mass means of 0.0189g for pH 4, 0.0317g for pH 5, and 0.0360g for pH 6. The ANOVA test resulted in  $F=5.38$  and  $p=0.0073$  (Table 3). The difference between the mean dry shoot mass of the radish plants grown in pH 4 versus the mean dry shoot mass of the radish plants grown in pH 6 was significant. Therefore, we rejected the null hypothesis that nitric acid has no effect on the dry shoot mass of radish plants and proved the alternative hypothesis that nitric acid has an effect on the dry shoot mass of radish plants.



**Figure 2.** The means of shoot length for pH4 was 14mm, pH5 was 20mm, and pH6 was 23mm.

Table 1. The result of the ANOVA Test the Shoot Length of Radish Plants

Source of variation	SSq	DF	MSq	F	p
pH	723.591	2	361.795	6.88	0.0021
Within cells	2944.545	56	52.581		
Total	3668.136	58			

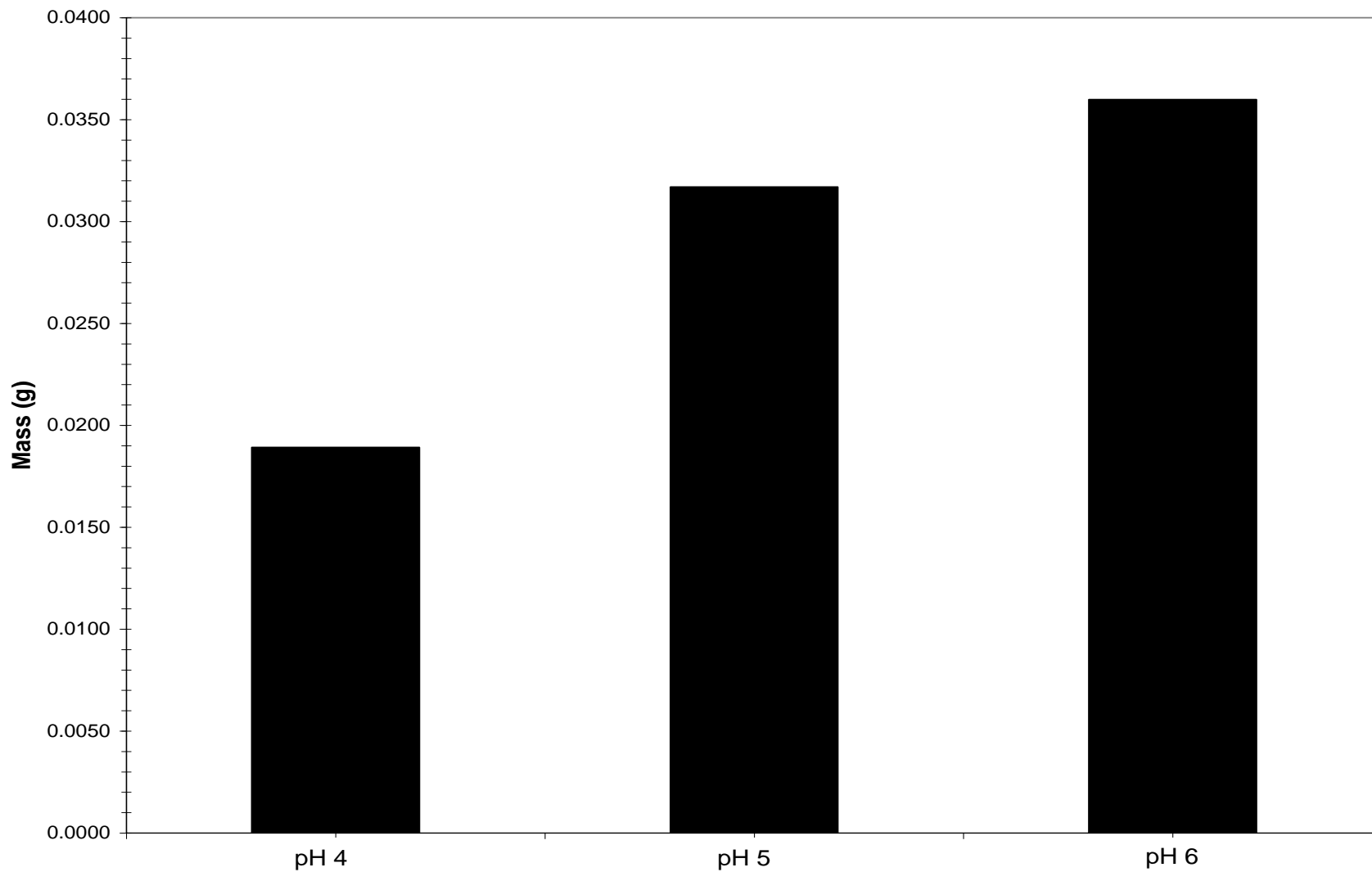


**Figure 3.** The means of root length for pH4 was 35mm, pH5 was 50mm, and pH6 was 44mm.



Table 2. The results of the ANOVA Test on the Root Length of Radish Plants

Source of variation	SSq	DF	MSq	F	p
pH	1836.839	2	918.420	1.77	0.1800
Within cells	29083.703	56	519.352		
Total	30920.542	58			



**Figure 4.** The means of dry shoot mass for pH4 was 0.0189g, pH5 was 0.0317g, and pH6 was 0.0360g.

Table 3. The results of the ANOVA Test on the Dry Shoot Mass of Radish Plants

Source of variation	SSq	DF	MSq	F	p
pH	0.00257	2	0.00129	5.38	0.0073
Within cells	0.01337	56	0.00024		
Total	0.01594	58			

## DISCUSSION

Our research indicates that low acidic pH's affects the roots (Salsbury and Ross 1978). However, the results of our experiment show that the root length of radish plants was not significantly affected by nitric acid of pH's 4, 5, or 6. Therefore, it is likely that the roots were not measurably affected by pH.

Our experiment showed that pH had a significant effect on radish shoot length and dry mass of the shoot. It is also possible that pH would have a more pronounced effect that we measured, since the particular acid we used also helps provide nitrates to the soil (Starr 2006). Since there was more nitric acid in the lower pH's, it could mean that those plants would have also gotten more nitrates, which help fertilize the plants. However, our data does not prove nor disprove this happening.

The radish plants were only susceptible to wet acid deposition in our experiment. If there would have been nitric acid in the air, like Miller (2005) says it travels, the plants may have grown differently. Also, our soil already had fertilizer in it, so some of the nitric acid would have been eliminated before it even reached the root (Starr 2006).

Growing the radish plants for only twelve days also could have affected our experiment. If they could have grown for a longer period of time, the differences of the growth of the plants might have been more obvious. The longer growth time would have allowed more acid to build up in the soil, therefore causing more harm to the semipermeable membrane and the ability of the plant to absorb nutrients (Considine 2002).

## LITERATURE CITED

- Barnhart, R.K. 1986. The Dictionary of Science. Hammond Inc., Maplewood, New Jersey.
- Considine, G.D. 2002. Nitric Acid. Pages 2458-2459 in G.D. Considine, editor. Van Nostrand's Scientific Encyclopedia. John Wiley and Sons Inc., New York, New York.
- Lambers, Hans and Chapin, F. Stuart. 1998. Plant Physiological Ecology. Springer-Verlag New York Inc., New York, New York.
- Raven, P.H. and Johnson, G.B. 1988. Acid Rain. Page 460 in D.K. Brake, editor. Understanding Biology.. Times Mirror/Mosby College Publishing, St. Louis, Missouri.
- Salisbury, F.B. and Ross, C.W. 1978. Plant Physiology. Wadsworth Publishing Company, Inc, Belmont, California.
- Starr, C. 2006. Nitrogen Cycle. Pages 746-747 in C. Starr, editor. Biology Concepts and Applications. Thomson Brooks/Cole, Belmont, California.
- Weier, T.E. 1974. Absorption of Water. Pages 162,189, 191 in W.W. Robbins, editor. Botany: An Introduction to Plant Biology. John Wiley & Sons, Inc., New York, New York.