

Measuring and Managing Soil pH

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This seminar will be presented to you in a format which hopefully covers many of your soil pH questions. Over the past few years, I have been questioned about soil pH, and this seminar is a compilation of questions which were asked. The key to managing soil pH is to understand how it affects plant and soil functions. pH is a very important topic in cranberry production, yet the understanding of pH is minimal. Through the use of a question and answer presentation, I hope to give you direct answers to many of your pH questions.

What is pH?

pH is a measurement which defines the acidity (acid) or alkalinity (base) of a soil solution. The amount of acidity primarily depends on the concentration of hydrogen (H^+) and hydroxyl (OH^-) in the soil. As soils get more acidic, the H^+ concentration increases, and this results in a lower pH. At pH 7 the concentration of acid (H^+) equal the amount of base (OH^-), and this is considered neutral. As pH increases, H^+ concentration decreases, OH^- concentrations increases, and the pH increases. This table outlines a range of pH and their concentrations of H^+ and OH^- .

		Acid H^+ concentration	Alkaline (Base) OH^- concentration
very acid	pH 1	0.1	0.000000000001
	pH 4	0.0001	0.0000000001
	pH 5	0.00001	0.000000001
	pH 6	0.000001	0.00000001
neutral	pH 7	0.0000001	0.0000001
	pH 9	0.000000001	0.00001
	pH 13	0.0000000000001	0.1

How is pH concentration measured?

pH is measured in log units, which is similar to the Richter scale for earthquakes. Each increase of 1 pH unit is actually decreasing the H^+ concentration by 10 fold. As an example, at pH 4, there are 1000 times more H^+ ions in the soil than at pH 7.

Why do some soils have a high pH and others have a low pH?

pH measures hydrogen (H^+) and hydroxide (OH^-) concentrations. Depending on the type of mineral that makes up your soil, a particular soil can naturally have a given low pH. These soils contain a natural abundance of H^+ which keeps soil pH at a particular level. Some of these soils with high organic matter, like a peat bed, has this natural level of H^+ which keeps soil pH low.

What is the optimum pH for growth of cranberry plants and why is this important?

The best pH range for cranberries is 4.2 to 5.5. This is considered very acid when compared to other cropping soils. Plant growth tends to decrease when pH levels are outside this range. The pH of the soil is closely linked with the availability of nutrients to the plant. Within this optimum pH range for cranberries, pH determines the behavior of certain nutrients, making them either available or unavailable.

Why do cranberries grow in low pH soil?

Cranberries evolved in soils where other plants could not grow. They adapted their root systems to tolerate certain elemental concentrations which would kill most other plants. Manganese and aluminum levels are increasingly available as soil pH decreases. Cranberries are tolerant to these high levels of manganese and aluminum, and they live while most other plants would die. This is how they adapted. Likewise at low pH, phosphorus, magnesium, calcium, and molybdenum are less available. Cranberries have adapted themselves to survive on low levels of these nutrients, as compared to other crops, which sometimes need concentrations of nutrients 10 times higher.

When pH is too high, how is the cranberry plant affected?

As pH in a soil increases, there are many nutrients which become increasingly available. Sodium, magnesium and calcium become increasingly available, and are thought to disrupt the balance of nutrients available to roots, and cause a type of toxicity. This nutrient imbalance is not good for cranberries, because they were not adapted for extracting their nutrients from those soils.

Why does the pH of some sandy soil fluctuate, while the pH on a peat soil remain steady?

The answer is in your soil's CEC, the cation exchange capacity. In simple terms, this means that peat soils have a larger amount of reserve H⁺ and other nutrients (such as phosphorus) which buffer the pH change. This keeps the soil pH stable. Sandy soils have low CEC and thus very little buffering capacity. These soils can fluctuate depending on the amount of H⁺ leaching through the soil.

What are the effects of high soil pH on my nitrogen fertility program?

Nitrogen is applied to cranberries in the ammonium form (NH₄⁺). Cranberries primarily use ammonium as their sole nitrogen source. In low pH soils, the nitrogen stays in the ammonium form. However, at pH > 5.5, the ammonium form is converted to nitrate, which is not utilized efficiently by cranberries. Likewise, nitrate is very leachable through the soil.

Can the soil pH in a newly planted bed adjust itself naturally?

I have seen beds with high pH levels (due to liming) decrease when flooded. Essentially, the acidic water supply flushed out much of the alkaline ions which originally caused the high pH. The soil was naturally acidic, and it returned to its natural level of pH 5.0. No other modifications were necessary.

If I have a high pH soil, can it be adjusted?

Yes, but if you have a high pH, that means you have more (OH) than (H+) in your soil system, and you will have to add sulfur which increases the H+ concentration.

What is the best product for lowering soil pH?

Elemental sulfur (ex. DS-90) is an excellent choice for lowering soil pH. Cranberry plants are adapted to tolerate high levels of sulfur in the soil system. Actually, sulfur is a required plant nutrient for cranberry growth, so the application of sulfur will not harm cranberry plants.

How does sulfur lower soil pH?

Sulfur combines with water and oxygen to form and sulfuric acid H₂SO₄. This acid contains H⁺ ions which go into solution and lower the soil pH.



Is this conversion a chemical or biological reaction?

The conversion to lower pH is bacterial. Sulfur is oxidized to sulfate by sulfur-oxidizing microorganisms. Its name is *Thiobacillus thiooxidans*. It is a bacteria which is always in the soil at low levels, and when sulfur is applied, they build up their populations to convert the sulfur to sulfuric acid (H₂SO₄). This acid (H⁺) then lowers soil pH. It is important to note that this reaction takes time. The bacteria may require several months to convert all the elemental sulfur to sulfate. Thus, pH levels should drop throughout the season if elemental sulfur is still available.

How much sulfur can I put on my cranberries?

When putting sulfur on established cranberry beds, the university recommends a maximum of 500 lbs per acre, split equally between two applications. Maximum applications of 250 lbs per acre should be in early spring after the last flood, and again in mid-late July.

Will high concentrations of sulfur hurt my cranberries?

We know that split applications of 250 lbs. per acre for a total of 500 lbs per acre per season will not hurt your established bed. Applying higher rates without incorporation will concentrate the sulfur on the surface of the bed and could hurt the plant. Studies which focus on the maximum rates of sulfur application have not yet been concluded. Actually, it probably won't be necessary to ever annually apply more than 500 lbs of sulfur. The bacteria must convert this to acid (H⁺) and this takes some time. If you have a continuous battle with high pH from flood waters or irrigation, sulfur applications will be a yearly event. Until additional research is completed, don't exceed the university recommendations for sulfur applications.

Are there any potential problems concerning sulfur application?

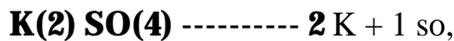
Sulfur needs to be oxidized to convert to sulfate. If applied in standing water, or saturated soils, sulfur may be reduced to H₂S gas, which smells like rotten eggs. I suggest you apply the sulfur when the vines are dry, then water in the material. If you plan to flood the bed for frost protection, delay the sulfur application.

Are there any other materials which can reduce soil pH?

Yes. An aluminum sulfate product, Al₂(SO₄)₃ will lower soil pH, but it would take 3500 lbs. per season to do the same as 500 lbs. of elemental sulfur. The pH drop will occur much more quickly than using sulfur. However, the aluminum levels could possibly be toxic to cranberry plants. I don't suggest you try this product for pH control.

Will potassium sulfate (K₂ SO₄) decrease my soil pH?

Absolutely not. Potassium sulfate contains sulfur, but it is already converted to the sulfate form (SO₄), and no hydrogens can be released to drop the soil pH.



Will supplying ammonium (NH₄⁺) nitrogen help my soil pH?

Yes, but the plant must take up the ammonium nitrogen to adjust pH. When the plant root takes up an ammonium ion, it removes a hydrogen (H⁺) and discharges it into the soil solution. This hydrogen will lower the soil pH.



Can the pH get too low?

Yes, studies I have conducted show that plant growth is slowed when pH drops below pH 4.2. I have grown cranberries to levels as low as 2.9, but at that pH, the H⁺ is actually toxic, and causes plant death.

What can I do about a low soil pH?

If you feel that your pH is too low, it is best to bring up the pH slightly with a good grade of finely ground agricultural lime. I have seen 50 lbs per acre of lime raise the pH of a bed 0.5 pH units, and increase crop growth.

Will my soil pH be affected by irrigating with a high pH water?

Every time you irrigate with a high pH water, you are slowing increasing your soil pH. The amount of increase depends on your soil CEC. As long as your soil pH does not get above pH 5.5, you are fine. Periodic measuring of soil pH will let you know how much pH change happens after a few weeks of irrigation.

How does flooding affect my soil pH?

When you apply a lot of water on at once, the soil structure is filled to capacity. Nutrients and other ions in the soil solution will dissipate into the flood water, and the pH of the flood water could modify your soil pH. If your soil has a low CEC (holding capacity), and your flood water has a high pH, your soil pH will probably increase. This is the reason that some growers may need to apply sulfur on an annual basis.

Prior to planting, can I adjust the soil pH of a bed with high pH?

Yes. I suggest that you apply sulfur into the soil where you can work it in. If your soil pH is about 6.0, apply 500 lbs per acre and incorporate it into the top 4 inches of soil. If your soil pH is at 7.0 or higher, apply 1000 lbs. per acre and make sure it is well incorporated.

What instruments can be used to measure soil pH?

An electronic pH meter is your most accurate method for testing soil pH. There are many types of pH testers available which range from \$60 to \$300. The more expensive they get, the more accurate they are, or more functions they perform. For doing occasional testing, you don't need an expensive pH meter. I suggest that you invest in a pH meter with an accuracy of +/- 0.1 pH unit. If the actual soil pH is 4.8, your meter will read between 4.7 and 4.9.

How do we measure soil pH of a bed?

Take 10 samples of soil from the bed, each about 4-6" deep. Mix well in a clean bucket, removing all plant material and large rocks. Combine 1 cup of distilled water with 1 cup of the soil. Mix well for 1 minute, then let it settle for 2 minutes. Submerge the probe into the solution, and read the pH.

How often should we test the pH of our beds?

If you feel that you have a pH problem, checking every month is a good idea. The data will allow you to determine how effective your sulfur applications were on the soil pH. Remember, don't expect the sulfur to work immediately. The bacteria must convert the elemental sulfur to sulfate, which then releases the H⁺ ions and lowers the pH. Over the course of a season, you should be able to determine the difference with your pH analysis.