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PRESIDENT VAN HOF: Now we will continue with our interesting program, and it is a real pleasure to give you Dr. Wallace A. Mitcheltree to talk on Soil pH: What It Is, How to Measure It, and How to Change It. Dr. Mitcheltree is from Rutgers University.

### THE MYSTERIES OF pH

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"pH" means "potenz" Hydrogen or strength for Hydrogen. It is a German term devised by a German chemist to explain the measurement of acid in a media. pH is a chemical term and when one thinks in terms of Chemistry he must think in terms of Electricity and when thinking in terms of Electricity you think in terms of "plus" and "minus" electrical charges. We go back into our high school Physics, - we learned that there was a law in the study of magnetism that said, "Like poles repel each other and unlike poles attract each other". The same law holds in Electricity that "Like charges repel each other and unlike charges attract each other." Two magnets that are placed in such position that like poles are opposite each other repel each other and force one magnet away from the other. If the magnets are so arranged that the unlike poles are opposite each other, then there is an attraction and the two magnets are immediately attracted together.

In chemistry, for instance, water has the formula of  $H_2O$ . If it were written structurally it would be written as HOH. Water is written structurally as HOH because it is made up of Hydrogen which has a plus charge  $H^+$  and Hydroxal which has a negative charge  $OH^-$ .

Hydrogen in the gaseous form as an element is an explosive gas. Hydroxal is a white, elusive liquid very few people have had the opportunity of seeing. It is an extremely unstable ion. When the Hydrogen and the Hydroxal are brought together, the positive charge of the Hydrogen attracts the negative charge of the Hydroxal and they immediately attach themselves to each other, forming a highly essential and relatively indestructible and extremely stable compound called Water HOH.

The essential component of all acid is Hydrogen. An essential component of all hydroxides or alkalies is Hydroxal. Water, therefore, has the main components of the two absolute opposites in Chemistry. It has the main component of acid which is Hydrogen  $H^+$  and the main component of an alkali which is Hydroxal  $OH^-$ . Water, therefore, when pure, would have a neutral pH - a pH of 7.0 because it would have the same number of Hydrogens and the same number of Hydroxals.

If we were to take the same Hydrogen ion that we had in Water and attach it to a Chloride ion, Chloride being the main component of Chlorine, which when in the gaseous form is a World War I poisonous gas, bringing these two together  $H^+ Cl^-$ , we form Hydrogen Chloride or Hydrochloric Acid  $HCl$ . If this Chloride had been attached to a Potassium ion  $K^+ Cl^-$  it would have formed Muriate of Potash  $KCl$  or Potassium Chloride, which is a neutral salt. It is a Hydrogen in combination with Chlorine that forms the strong Hydrochloric Acid.

Another basic factor of Chemistry is the fact that these ions are in constant movement when they have the opportunity and are bouncing back and forth within the attraction zone of their various charges. In other words, if one were to pour some Hydrochloric Acid into a waterglass, the Hydrogen and the Chloride would not remain together but would operate separately, bouncing back and forth rather rapidly within the confines of the glass. We still, in this instance, have the same number of "plus" and the same number of "minus" charges even though they are not strictly combined into what we think of as a Hydrochloric Acid molecule. This separation and action of the ions, one to the other, is referred to by the chemists as "ionization" or "dis-association". In other words the ions disassociate from each other but remain within the confines of the container.

There are basically two types of acids - mineral acids and organic acids. The basic difference between these acids is that the organic acid is slightly ionized while the mineral acid is referred to as being highly ionized. Mineral acid, such as Hydrochloric Acid ( $HCl$ ), Sulphuric ( $H_2SO_4$ ) and Nitric ( $HNO_3$ ) are all highly ionized, almost completely dissociated and highly susceptible to reacting with some other ion that may be introduced into their midst.

The organic acids are slightly ionized, or in other words, do not split up or dissociate to the same degree as the mineral acids. When an organic acid is poured into a glass, a small number of the Hydrogens split up and operate separately, but the bulk of the acid remains in the molecular stage, not dissociated and not nearly as highly reactive when some other ion is introduced into the container. In the case of Carbonic Acid,  $H_2CO_3$  less than half of one percent would probably ionize with a few single Hydrogen ions and a few single  $HCO_3^-$  ions floating around,  $H^+ HCO_3^-$  and the bulk of the acid in the  $H_2CO_3$  combination.

Examples of organic acids are Carbonic Acid ( $H_2CO_3$ ), Acetic Acid ( $CH_3-COOH$ ) and Oxalic Acid ( $HO_2C.Co_2H$ ). The strength of an acid is measured by the amount of Hydrogen in a given volume. In Chemistry a liter is a basic measure and when a gram milliequivalent of Hydrogen is in a liter of an acid, the acid is a normal acid or said to be 1 normal.

pH is a measurement of Hydrogen - ionized Hydrogen in a solution. The pH meter, through the use of electrodes or terminals, counts the number of free-floating Hydrogens in the solution. In other words, it counts the dissociates or the ionized Hydrogens that are not attached.



A highly ionized mineral acid of 1 normal strength, and a slightly ionized 1 normal organic acid would have identically the same strength and require the same amount of alkali to neutralize them. However, if one were to measure the pH in a mineral acid they would find that it would have a very low pH because the machine would show a great number of free-floating Hydrogen ions that had been dissociated or ionized whereas in the organic acid the pH meter would register a higher pH since there would be many less free-floating or dissociated Hydrogen ions. This is one of the basic differences, therefore, in the two types of acid, and it is a place where we frequently run into trouble when interpreting the pH of a soil. If a soil has been in sod for a great many years, had a good bit of raw organic matter plowed back and received very little if any, commercial chemical fertilizer, it is conceivable that a great deal of the acids in that soil would be organic acids, which would require a given amount of time to counteract. However, the pH meter would register a considerably higher pH than if this soil had been managed without organic matter and completely with commercial fertilizers that had created strong mineral acids in the soil, even though the total acidity was the same in both cases.

The expression of the measurement of pH in itself is not simple. We know the pH scale is a straight line divided into fourteen (14) equal parts running from zero to 14. Seven is in the exact middle of this scale and is a neutral pH. Everything from 7 down to zero is acid, getting progressively more acid as we approach zero; everything from 7 to 14 is alkaline and getting more alkaline as we approach 14. As we said when discussing the formula of Water, that Water had the same number of Hydrogens as it had Hydroxals and, therefore, it was neutral and has a pH of 7.0. A pH of 1 would have considerably more Hydrogen than Hydroxals in order to make the solution more acid. A pH of 13.0 would have considerably more Hydroxals than Hydrogens in order to make the solution more alkaline.

If we were to try to express this ratio of Hydrogen to Hydroxals in pounds or grams it would be extremely unwieldy, therefore, the chemists went to the mathematician and borrowed the logarithm scale. When we are working with something that is less than one (1), logarithms can be expressed as  $1 \times 10$  to the minus sub-number, the sub-number meaning the number of digits to the right of the decimal point. In other words,  $1 \times 10^{-1}$  would give us a concentration of 0.1.  $1 \times 10^{-3}$  would give us a concentration of 0.001. In the case of  $1 \times 10^{-5}$ , it would give us a concentration of 0.00001. In the case of  $1 \times 10^{-1}$ , one could say that this is one-tenth of a percent concentration or one-tenth of a pound, or one tenth of a gram.  $1 \times 10^{-3}$ , one could say that this is one-thousandth of a percent, or of a gram or of a pound. In the case of  $1 \times 10^{-5}$ , one could say that it is one-one hundred thousandth of a percent, or a pound or a gram. This is unwieldy enough at this level, - what would it be and how would you designate  $1 \times 10^{-14}$ , where it is written 0.00000000000001. The chemists who devised the pH scale therefore, took the sub-numbers off the  $1 \times 10^{-}$  and made the pH scale of these numbers. Therefore,  $1 \times 10^{-1}$  shows a concentration of one-tenth of a percent Hydrogen and one times 10 to the -14 would be 0.00000000000001 percent Hydrogen. It now becomes evident that the

larger the number on the pH scale the smaller the percentage of Hydrogen, because 0.000000000000001 is considerably less Hydrogen than 0.1 percent Hydrogen. The pH scale, therefore, becomes a reciprocal of the actual concentration and a pH of 1 is considerably more acid than a pH of 6. Another factor that will come out later in the discussion is that the amount of Hydrogen between  $1 \times 10^{-2}$  or 0.01 and  $1 \times 10^{-1}$  or 0.1 is not just twice as much Hydrogen but 10 times as much. In other words there is 10 times more Hydrogen in a pH 1.0 as in a pH 2.0.

How do we neutralize an acid? We take HCl, which is a mineral acid, highly ionized, with equal amounts of Hydrogen and Chloride, and we neutralize it with some alkali, which is an opposite to the acid. Let us take alkali commonly known to farmers, such as Calcium Hydroxide, which is really Hydrated Lime. If we put Calcium and Hydroxal  $\text{Ca}^{++}\text{OH}^-$  together we find that something is wrong because the Calcium has two plus charges and Hydroxal has only one negative charge. You must, therefore, arrange for two Hydroxals to join with the one Calcium so as to have two negative charges counteracting the two positive charges of Calcium.  $\text{Ca}^{++}\text{OH}^-$  or  $\text{Ca}(\text{OH})_2$ .

Now, if we have one molecule of Calcium Hydroxide and one molecule of Hydrogen Chloride to react together, we find that on the alkali side we have two plus charges and two negative charges and on the acid side we have only one plus and one negative charge.  $\text{H}^+\text{Cl}^-$   $\text{Ca}^{++}\text{OH}^-$ . Therefore, in order to balance the equation properly, we are going to have to use twice as much acid as alkali.  $\text{H}^+\text{Cl}^-$   $\text{Ca}^{++}\text{OH}^-$ . We now have two plus charges in the form of Hydrogen on the acid side, and two negative charges in the form of Chloride on the acid side; two plus charges in the form of Calcium on the alkaline side and two negative charges in the form of Hydroxal on the alkaline side. When these compounds react with each other, there is a simple exchange of the Calcium tying up with the Chloride and the Hydrogen tying up with the Hydroxal  $\text{Ca}^{++}\text{Cl}^-$   $\text{H}^+\text{OH}^-$  forming one molecule of Calcium Chloride with two plus charges and two negative charges, and two molecules of Water, each molecule having one plus charge of Hydrogen and one of Hydroxal, or a total of two plus charges in the Hydrogen form and two negative charges in the Hydroxal form. The results of this reaction now, instead of having an alkali and an acid, has a neutral salt, Calcium Chloride  $\text{CaCl}_2$  and Water, Hydrogen Hydroxal (HOH) which is neutral and has the same number of Hydrogen and Hydroxal charges which counteract each other. The strong acid now has been counteracted to a neutral compound with the use of a strong alkali. The same situation takes place in an acid soil.

Soil is made up basically of sand, silt, clay, organic matter, air, and water. The clay and the organic matter are chemically active and contain negative electrical charges. The negative electrical charges on the clay and the organic matter in the soil are satisfied by positively charged ions, such as Hydrogen, Calcium, Magnesium, and Potassium. If we have a soil that is very acid, these negative charges are predominantly loaded with Hydrogen, since Hydrogen is the main component of an acid. A particle of clay or organic matter can be visualized as having these negative charges around its outside



surfaces and in soil there is a film of water around each one of these particles. This film of water acts very much as a glass of water and the Hydrogen, here in this particular case, operates exactly as it did when we poured the acid into a water glass. A certain amount of it dissociates and floats around separately within this film of water. In other words, the Hydrogen in this soil is ionized the same as it is in the water glass. When we check the pH of a soil, the pH meter does the same job here as it did in the water glass. It counts only those Hydrogens which are floating in the film of water separately.

We assume when we run the pH, therefore, that if there are a certain number of these Hydrogens floating around in the film, that there must be a certain given number Hydrogens attached to the clay or organic matter particle. This is an estimate that is made from past experience in working with soils and their chemical properties. The pH, therefore, does not give us the total acidity of that soil but it gives us the active acidity or the ionized Hydrogen and we must, from experience and knowledge, interpolate what we think is a reasonable number that would be attached to the clay and organic matter and then compute from these two, the actual measurement of the ionized Hydrogen and the assumed measurement of the attached or associated Hydrogen, as the total acidity of that particular soil. We therefore calculate the amount of Lime that would be necessary to raise the pH to where we feel would be desirable and then introduce this amount of alkali or Lime into the soil in order to do the job that we are trying to accomplish. In neutralizing an acid soil with a Hydrogen clay, we will use Calcium Hydroxide again, since the chemical reaction is a little less complicated and a little easier to understand. Normally, we recommend the use of Calcium Carbonate, but the Calcium Hydroxide reaction is a simpler reaction and is basically the same reaction that takes place and Calcium Hydroxide or Hydrated Lime is also a commonly used liming material. When Calcium Hydroxide is introduced into the soil, as liming material, the same reaction takes place as when we introduced it into Hydrochloric Acid.

$$\begin{array}{l} \text{H}^+ \text{ Humate} \quad \text{Ca}^{++} \text{OH}^- \\ \text{H}^+ \text{ Clay} \quad \quad \quad \text{OH}^- \end{array}$$
 The Calcium splits off from the Hydroxide and satisfies the negative charges on the Humate and Clay, the Hydrogen leaving the Humate and clay and going to the Hydroxide, forming water.

$$\begin{array}{l} \text{Ca}^{++} \text{Humate} \quad \text{H}^+ \text{OH}^- \\ \text{Clay} \quad \quad \quad \text{H}^+ \text{OH}^- \end{array}$$
 We now have a Calcium clay and Humate, which takes the place of the neutral salt, and water, which of course is neutral.

In order to ascertain the right amount of Lime to neutralize the acidity, this necessitates coping with another rather difficult problem. In order to determine the total acidity of a pH measurement we must know the amount of Humate and Clay that is in the soil. We find that a soil which has a pH of 6.0 to 6.5 has the negative charges satisfied with approximately 65 percent Calcium, 20 percent Hydrogen, 10 percent Magnesium, and 5 percent Potassium. Now then, if a soil has 55 percent Calcium, and 30 percent Hydrogen, our job is to reduce the Hydrogen and raise the Calcium proportionately. How much Lime does this take per acre?

In a heavy clay soil, there is generally a rather large amount of organic matter, due to the natural soil-forming processes. With a large amount of clay and a large amount of organic matter, we would therefore, have a considerable number of negative electrical charges. In a sandy soil, with a small amount of clay, again because of the natural soil-forming processes, we frequently have a relatively low amount of organic matter. This small amount of clay and a small amount of organic matter would, therefore, have a relatively small number of negative electrical charges. Let us take a "for instance".

If we had a soil with 100 negative electrical charges and were to raise the percent saturation from 55 percent to 65 percent we would have 10 negative electrical charges to change and this would require five (5) Calciums, since Calcium has two positive charges. Now, on the other hand, if we had a soil that had a thousand negative electrical charges, to raise that from 55 percent to 65 percent would be 100 negative electrical charges to replace rather than 10 and it would, therefore, require 50 or ten times as many Calcium ions to do the job.

There are ways of determining the number of negative electrical charges in a soil, but it is a very long, drawn out and difficult analyses. Therefore, through experience and research we have learned to estimate this, and someone with plenty of experience can estimate this relatively closely. It is, however, a variable that causes our liming recommendations to be not an absolute thing but a good calculated, educational guess.

Another factor that can be thrown into the pot as causing difficulty in trying to develop a perfect recommendation each time, is the fact that pH varies. It varies both from day to day and from place to place in the soil.

Soil is a natural, heterogeneous geologic body and anytime we work with a material of this nature, we find that there is considerable variation in it. The pH of a soil is a natural equilibrium which develops over millions of years. Man can change it temporarily but it will constantly fight to get back to its natural equilibrium. This can be compared to our outside weather or climate and a man building a house to protect himself from this weather and climate. If a man lives out in the weather and climate, at all times, he must adjust himself to this. He builds a house to protect himself from the rigors of weather and its changes. Just building a shell of a house does not prevent the temperature from the inside of the house being the same as the temperature on the outside, nor the inside of the house getting just as cold as it does outside. So, in the house, he puts a stove, which in turn heats the house. So long as he continues to bring in wood, and put it in the stove, he maintains a temporary change of temperature in the house from that outside. But the minute he gets lazy and does not bring in wood, and lets the fire go out, the temperature immediately reverts back to the equilibrium of the outside temperature. Now, when he does have the fire built in the stove in the kitchen, he has a certain temperature near the stove. But if he were to hang a dozen different thermometers in the living room, in the



bedroom, and in the corners of the kitchen as well, he would find that no two thermometers would register the same temperature, because the heat has not been equally distributed throughout all corners of the house. It is true, it would be warmer in some of the corners, but not as warm as near the stove. This same affair happens inside of soils that have been limed. The temperature or the pH is not identically the same in all areas.

As this fire dies down and before he gets it rebuilt again, the temperature will drop and as soon as he adds more wood to the fire, it will immediately come back up, so his temperature is not constant; it varies from day to day and from hour to hour. The same is true with the pH of the soil.

Now, if one were to try to average the temperature in a house, he would read all of the thermometers, add up the total temperatures and divide by the number of thermometers and he would have the average temperature of that house. Remember now, that not all areas are the same, but he does now have an average temperature for his house, which is the thing we must do when making recommendations for using Lime on an acre of land. We must use the average conditions.

Since the pH, as we measure it, is not a straight arithmetical factor but that each pH is ten times greater than the pH next to it, we cannot add these and divide and come out with an average. Still, we must have an average pH for a field. The way we average the pH for a field is to take sub-samples in ten or 15 different places throughout the field, throw these samples of soil into a bucket and stir them up and mix them as well as possible, and then take a representative sample of these sub-samples. This we analyze and consider our average pH for the area. As you can see, it is highly essential and very important that a good average be made. Therefore, a good sample must be taken. If he were to take temperature readings near the stove, and have only one sample, he would certainly not have a very good average of the temperature of his house.

Just what does pH do in the soil? pH is the adjustment valve on the releasability of nutrients. In very acid conditions, Iron, Manganese, and Aluminum are extremely soluble and are highly available to the plant. They are so available to the plant that they become toxic to it and retard its growth. In a soil of a relatively high pH of between 7.0 and 7.5, the Iron, Manganese and Aluminum are thrown completely out of solution and become unavailable to the plant. At this point, instead of being toxic to the plant, the plant is suffering from a lack of nutrients and will have deficiency symptoms showing up and a retardation in growth. The only natural source of Nitrogen in soil is organic matter. At very low pH's, the micro-organisms that decompose organic matter cannot function properly and, therefore, do not break down the organic matter very rapidly and consequently little natural Nitrogen is released. In extremely high pH's, the soil is too alkaline for the micro-organisms of the soil to function properly. Here again, organic matter is not broken down and we do not get the return to the natural Nitrogen from organic matter decomposition that we should.

At very low pH's when the Iron and Aluminum are extremely active, they react with the Phosphorus, forming Iron-Aluminum Phosphates which are extremely insoluble and unavailable to plants and the plant, therefore, suffers from the lack of Phosphorus. At an extremely high pH there is sufficient Calcium in the soil that the Phosphorus reacts with the Calcium, forming Tri-Calcium-Phosphate, which also is insoluble and unavailable to the plant.

When we adjust the soil with the use of Lime so that the pH lays between 6.0 and 6.5, we have just enough Magnesium, Iron, and Aluminum to satisfy the plant, yet it is not in toxic amounts. We have the most favorable microorganism climate and, therefore, the organic matter is decomposed most rapidly and we get our greatest return from Nitrogen release.

In a zone of 6.0 to 6.5 the Phosphorus is neither being tied up by Iron and Aluminum to any excessive amount nor is it reacting with the Calcium and it stays in the Mono- and Di-Calcium form which is readily available to plants. pH is, therefore, the adjustment valve in the soil. We adjust the soil by applying Lime and we measure our adjustment with the pH meter.

There is one other place where we do run into trouble in trying to ascertain the amount of Lime necessary to adjust the soil. Clay particles are thin plates and they resemble a stack of dinner plates. In certain soils these plates adhere very tightly together and between these plates are a large number of negative electrical charges and in an acid soil these negative charges are satisfied with Hydrogen. When Lime is added to the soil the Hydrogen from the outside of the "stack of plates" is removed and after the reaction is over, the reserve acidity between the plates is forced out to become active. The man could test the soil this year and find the pH to be 5.5, lime it, go back and test it next year, and find it had a pH of 5.5 again because the reserve acidity had come into play. He may lime it again and go back and check again later, and find the pH is still 5.5 because the reserve acidity has been pushed out. He might Lime again next year and suddenly find his pH goes up to something like 7.5 or 8.0, simply because all the reserve acidity had been removed and the total acidity of the soil was not nearly as great as ascertained by the use of the pH meter.

Someone who has had a lot of experience with soils can frequently determine this situation, explain it to the farmer beforehand and then allow a little longer waiting after an application of Lime has been made. In this particular case the equilibrium adjustment is slower and must be accounted for.

The acidity of soil is an extremely important phase in soil management. pH, at its best, is an estimate. Total acidity analyses of course are quite absolute. Since they are such difficult, slow, and expensive analyses, we sacrifice accuracy for speed and economy. When we do this, we must use in its place good training and vast practical experience. It is not difficult to make a pH analysis.



It is, however, quite difficult to make a good pH interpretation and recommendation from it. This needs knowledge and experience.

PRESIDENT VAN HOF: Thank you, Dr. Mitcheltree.

MR. RADDER (Bloomfield, Conn.): Didn't you say that the availability of iron is in relation to the pH?

DR. MITCHELTREE: Very definitely.

MR. RADDER: I have a problem where my pH was four and a half and I still had chlorosis.

DR. MITCHELTREE: I knew somebody would bring that up. When we get into this situation we apparently have another problem. Now this is an Ericaceous plant, I presume. Here again I am with people who know a lot more about this than I know, but let me say that on the ericaceous plants we have a symbiotic microorganism that grows on it. A lot of people have tried to work with it and never determined why it is there. I am still of the opinion that it must be somehow involved with the assimilation of iron.

Another thing we run into when we run into iron chlorosis at low pH is frequently garden centipedes, and I think maybe this nematode business. Any place these lighthaired feeding roots are taken off the plant I don't think the iron can get into the plant. We have run into lots of these cases, taken the soil and analyzed for iron and found all kinds of iron. It is there but the plant is not getting it. Therefore, it is something about the plant that gives the trouble, not the soil.

MR. C. H. HENNING (Niagara Falls, Ont.): Could you tell me about the relationship of adding gypsum as a substitute for lime?

DR. MITCHELTREE: Gypsum is a neutral salt, calcium sulphate. When it breaks down in the soil it forms sulphuric acid rather than water. The sulphuric acid counteract the neutralizing effect of the calcium. So gypsum cannot be under any stretch of the imagination considered as a liming material. It is a material that will add calcium to the soil. Once in a while we run into a soil that has a very low calcium saturation and extremely high pH from too much potassium or too much magnesium, so here we recommend gypsum to help bring the calcium into balance without affecting the pH. We also in New York recommend gypsum because of the flocculating action and will be of advantage in clay colloid and allows space for drainage.

MR. DeWILDE: Shouldn't you have a complete soil analysis if you are asking somebody to recommend a low pH?

DR. MITCHELTREE: I paid you \$5 for asking me this question, but I didn't think you would come up with it. In soil testing we want a complete analysis. We don't rely on a pH because the balance of the nutrients in it mean as much as this, as their presence is concerned. Don't stop with just the pH.

MR. DeWILDE: As a part of my question, is it true in a good many types when you have iron chlorosis or what the average person says is iron, that if you up the magnesium that the iron chlorosis will disappear?

DR. MITCHELTREE: In some plants it is very difficult to tell the difference between iron chlorosis and magnesium problems. You have to look carefully at the physiological position. I don't like these symptoms myself to go by. They are only indicative.

MR. JIM WELLS: Mitch, I have noted your comment about the value of aluminum on ericaceous materials. Would you elaborate?

DR. MITCHELTREE: Not very much, Jim, because I am not in a position to say positively that aluminum is valuable in ericaceous plants. However, people who have worked with ericaceous plants have indicated to me that they feel aluminum is essential. Aluminum is in the soil in two or three different forms. We do know that when we have low pH we always have a high availability of aluminum content.

MR. WELLS: What about the other trace elements? Do you think they are of vital importance?

DR. MITCHELTREE: All trace elements are of vital importance. Let me make this statement: Properly limed soil will eliminate 99.9 percent of all minor element properties. We will run into a modified minor element problem on other conditions but it is very slight. Liming is your big factor.

MR. KERN (Cincinnati): In southern Ohio all our soils are on a clay basis and our trouble is just the opposite. We have plenty of our lime. We have our pH sometimes running between 7 and 8 and mostly we are concerned with how to bring it down. We like 6.5 or something like that. What do we do to make that correction?

DR. MITCHELTREE: I am going to split your question into two phases. If we were on an acid soil, basically natural acid soil, and we raised the pH way up, we would expect trouble and we are going to have to do something about it. On most conditions with the naturally high pH soils that have developed under natural calcareous conditions, we don't run into these problems. I have seen salvias growing very nicely on 7.5 where the soils are limestone soils and have been calcareous throughout millions of years and we don't run into these problems. Why, I cannot tell you, but we did.

Now if you are experiencing this problem of iron chlorosis on a highly calcareous soil, the only thing we have to offer to you is the use of sulphur. I detest making this recommendation because when we put sulphur on a soil we recommend in New Jersey never to put more than 300 pounds per acre. Then you have to mix it with the soil to the very best of your ability because when you put sulphur on a soil you can get pockets of pH of 1 and down. I always am afraid of a sulphur recommendation, but if you have got to bring the pH down,



the only recommendation we have to date is sulphur, and never more than 300 pounds per acre.

MR. WALTER PEFFER (Trafford, Pa.): Will you please comment on the toxicity of dolemitic lime?

DR. MITCHELTREE: Dolemitic lime is simply a combination of calcium and magnesium carbonate. It has both calcium and magnesium. It ranges anywhere from 2 percent magnesium up to about 25 percent magnesium. 25% is about as strong as you can get. Dolemitic lime, in our estimation, is an excellent liming material. Some places we have to recommend it specifically because we have a major shortage. However, we have never had the experience of anybody getting toxicity from dolemitic lime.

MR. SHUGERT (Neosho, Mo.): Sir, we treated 35 acres of ground two weeks ago. It had a pH of 4.6. Two tons of brown limestone and 1,500 pounds of rock phosphate per acre. When do we take the next soil test?

DR. MITCHELTREE: I would recommend the next soil test be taken next spring.

PRESIDENT VAN HOF: Gentlemen, we will have to put a stop to this now and all the rest of the questions can go into the question box.

With thanks to Dr. Mitcheltree, we will close this session for today. Tonight at 8 o'clock, everybody is invited to come to the Special Session on Teaching by Harvey Gray. Thank you.

(The session recessed at 4:40 o'clock.)

#### FRIDAY MORNING SESSION

December 8, 1961

The third session convened at 9:30 o'clock, President Martin Van Hof presiding.

PRESIDENT VAN HOF: Please be seated. We have a tight schedule this morning, all day, in fact. Dr. Sylvester March will be moderator of the Speaker Exhibitor Symposium.

MODERATOR MARCH: Thank you very much.

As Martin said, we are on a very, very tight schedule and I would like to ask that if there are any questions we save those for this evening in the question box.

I would like to present the first speaker, David Leach of Brookville, Pennsylvania, who will speak on "Hardest and Best Rhododendrons for Commercial Propagation".