Agro-Facts

Agdex#530

SOIL SCIENCE

Improving Pacific Acid Soils Using Coralline Lime

The authors of this booklet are Alex W. Bekker, former Graduate Research Assistant and L. G. G. Yapa, Lecturer in Soil Sciences, University of the South Pacific, Alafua Campus, Apia, Western Samoa.

This publication was supported under
Grant No. 936-5542-G-SS-9092, programme in Science and Technology Cooperation, Office of the Science Advisor, US Agency for International Development.

Published September, 1994, by the Institute for Research, Extension and Training in Agriculture.

IRETA Publications
USP Alafua Campus
P.O. Private Bag
Apia, WESTERN SAMOA

Copy Editor: Emil Adams
Printer: Fa'aolataga Amosa

ISBN 982-175-030-3 5C

Introduction

"The wealth of a nation lies in her soils and their intelligent development."

For agricultural crops, soils is a medium capable of physically supporting plants as well as acting as a storehouse for water and nutrients essential for plant growth. A good understanding of soil is important when we want to improve agricultural production. Sometimes the yields are disappointing, or plants do not grow at all. Then, we want to know what might be the problem: not enough water, too much water, too hot or cold, or maybe the soil lacks nutrients.

If the soil is poor, we have to use fertilizers to make sure the plants have enough nutrients to grow. It is often good to apply some fertilizer to a field because, when we harvest crops, nutrients are removed from the soil. The fertilizer will put nutrients back into the soil.

Organic fertilizers, such as compost, chicken manure or cow dung contain all the different kinds of nutrients (about 16 all together). The common commercial fertilizers contain only a few of the nutrients that plants need. The nutrients most common in these fertilizers are nitrogen (N), phosphorous (P) and potassium (K). Often we can buy mixed N-P-K fertilizers which combine all these three nutrients. But plants also need nutrients like calcium (Ca), magnesium (Mg), sulphur (S) and some other nutrients which are required in small quantities or known as micronutrients (e.g. iron, manganese, zinc, and copper).

Sometimes, adding fertilizers (organic or commercial) may not solve the problem; then, it is better to test the soil to find out about the fertility of the soil. When we test soil, we may look at different things:

- how sandy or clayey is the soil?
- does the soil contain enough nutrients?
- does the soil contain enough organic matter?
- how about the ACIDITY of the soil?

Soil Acidity

When we test soil for acidity, we measure the soil pH. In an acid soil, the pH is low, i.e. less than 7.0. Crop production can decrease when the soil is very acid, e.g. less than 5.5. Most plants do not like a very low soil pH.

In an alkali soil, the pH is high, i.e. more than 7.0. Crop production can also decrease when the soil is too alkaline. Most plants do not like a high soil pH either.

The soil pH has to be just right, not too low, not too high. Luckily, most of the soils in the Pacific have a soil pH that is good enough for growing crops. But, in some places, we find very acrid soils where the soil pH is too low. In other places, mainly on coral atolls, we find alkali soils, their pH is too high for good crop production.

How Soils Become Acidic?

Rain is an important reason why soils become acidic. In areas with high rainfall, much water will go through soil. This water can slowly remove a lot of nutrients from the soil. They will be carried out in the rivers to the sea. At the same time, soil pH decreases and the soil becomes acidic.

Soils from a rainy area will not be very fertile. They need N-P-K fertilizers and/or organic fertilizers to make sure the plants get enough nutrients to grow. Sometimes these soils need other fertilizers as well. It is possible that too much calcium and/or magnesium has washed out of such soils. If this happens, such soils have calcium and/or magnesium deficiency. We need to add these elements back to the soil for crops to grow well again.

Why Plants Do Not Grow Well In Acid Soils?

When pH drops below 5.5 some red soils start to release a lot of aluminum. Many plant roots do not like aluminum. It is a poison to plant roots. This problem is called aluminum toxicity. If we can raise soil pH above 5.5, the aluminum toxicity will disappear and the plant roots will be able to develop again.

Similarly manganese also can be toxic under acid conditions; manganese toxicity is more common in Western Samoa than aluminum toxicity.

In some very acid soils, plant roots will not grow deep. The roots tend to remain in the top soil. These plants can dry out very quickly. Also, they can fall over easily when the winds are strong.

Common colours for acid soils are light brown/yellow and red.

Acid soils become a real problem when their pH is less than 5.5. They have low calcium and magnesium content and low availability of phosphorus.

Where Can We Expect Problems With Soil Acidity?

It is not possible to give one easy rule to determine which soils are too acidic for plants. However, there are some guidelines:

- very acid soils are found in areas with heavy rainfall, e.g. on top of mountains or on the side of a mountain facing the trade winds.
- in some cases it may come from the parent rock.

What Can We Do To Improve Acidic Soils?

As previously mentioned very acid soils are usually found in areas with high rainfall, and they are not very fertile. They have lost a lot of nutrients. To improve the growth of plants, we need to add fertilizers. Commercial fertilizers (N-P-K) are usually the easiest to apply. But in very acid soils, this may not solve our problem. These soils often need other nutrients as well, before the plants can grow well again.

Lime is a fertilizer that has a high pH and contains large amounts of calcium (and sometimes magnesium as well). When we add lime to an acid soil, a number of things can happen at the same time:

- the soil pH will increase,
- the aluminum and manganese toxicity can disappear again when the pH increases above 5.5,
- since lime has large amounts of calcium, it can take away the calcium deficiency of a soil,
- magnesium deficiency will also be taken care of, if we use lime containing magnesium,
- improves phosphorus availability in the soil,
- improves the physical properties of soil such as soil structure.

Liming the Soil

When we add lime to soil, it has to dissolve before it can work. A characteristic of lime is that is dissolves very slowly.

Very fine lime particles can dissolve quickly but the coarse lime particles are too big and will stay in the soil for a long time. But even if we use very fine powdered lime, it still takes at least one month of rainy weather before the lime has dissolved far enough. We can help to dissolve the lime by working it into the soil after application.

Liming Materials

Commercial lime: This is processed limestone, grounded very fine. All the particles will usually dissolve within 1-2 months, if the soil is wet enough.

Dolomite lime: Apart from calcium, this also includes magnesium. If the soil is low in magnesium, it is better to use dolomite lime.

Coralline lime: This is a white or grey material that breaks off from coral reefs which surround many of the islands in the Pacific. We can find it on beaches or in lagoons (Figure 1). It can be used for liming acid soils, and is as good as commercial lime if adequately used. Because coralline lime is usually not ground, it still has a lot of coarse particles. These bigger particles will dissolve much slower than the fine lime. Sometimes it can take 2-4 years before they dissolve. Thus, we need a larger quantity of coralline lime than of the commercial lime.

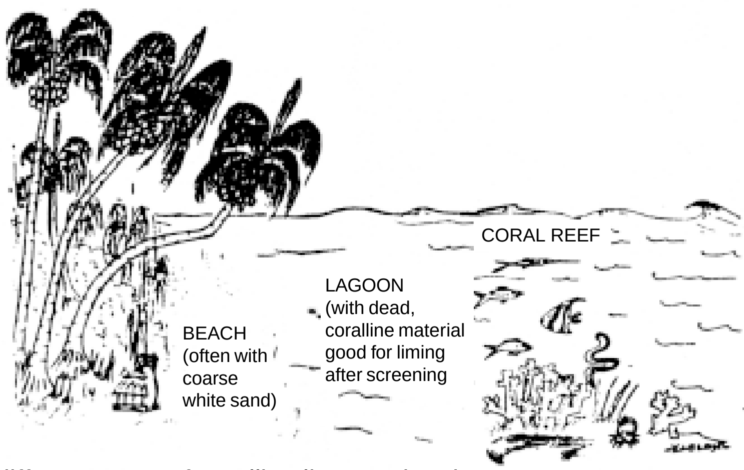

Figure 1. Location of different types of coralline lime on the shore

More about coralline lime

The size of the particles of coralline lime may vary from place to place. The amount of fine particles usually depends on the place where the coralline lime is found. If we look at white sand on a beach, we can still see that this sand is not very fine. If we want to use this coarse sand, we will need more of it. Also, we will have to wait for a longer period before the lime can dissolve.

If we look at the coralline material that we find in the lagoon between the beach and the reef, we can see that this has more fine particles. It may have very big chunks which we will need to remove before we can use this material as lime (Figure 2).

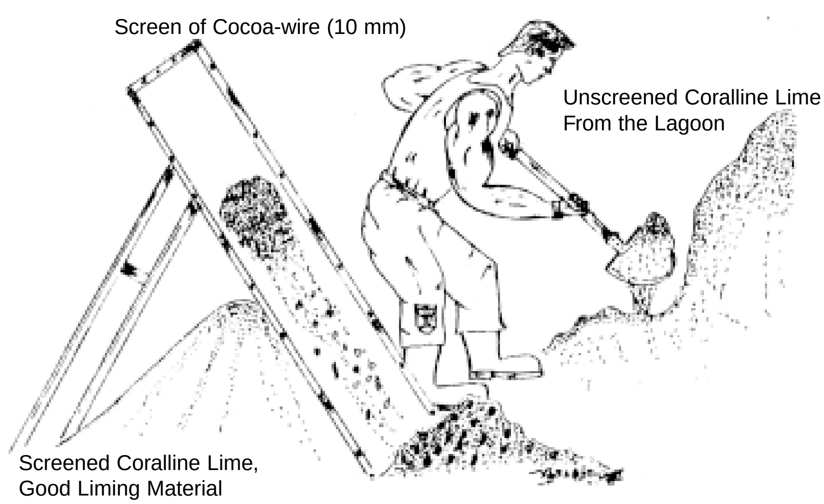

Figure 2. Screening coralline lime from the lagoon.

The particles that dissolve faster are smaller than 0.42 mm (40 mesh). A soil testing laboratory in your country, or the Soil Analytical Laboratory of U.S.P. Alafua, Western Samoa, can test the coralline lime to find the percentage of lime particles that are less than 0.42 mm.

Here is a simple partcle size test that we can do at home:

1. Fill a glass jar with water;

2. Add a handful of coralline sand that you want to test;

3. Stir the content of the jar well;

4. See how fast the sand sinks to the bottom again after we stop stirring.

Results:
A. If some sand settles quickly at the bottom (within a minute), but still a lot stays in the water making the water look muddy, then we know that this sand probably has 20-50% fine particles. We usually find this kind of coralline lime in lagoons.

B. If most of the sand settles down quickly, and only a little stays in the water, we know that this sand has almost no fine particles. This kind of coralline lime is found on most beaches, and is not good as liming material.

How Much Lime Is Needed?

We can learn from a soil test if a soil has problems with calcium deficiency and/or aluminum toxicity. When soil-calcium is low (i.e. less than 2 cmol(+)per kg), we can expect calcium deficiency. When the pH is les than 5.5, and at the same time, soil-aluminum is high, we can expect aluminum toxicity. Calcium deficiency and aluminum toxicity are different problems which need different amounts of lime to correct them.

From the following table we can learn how much of the different kinds of lime is needed on soils that have problems with calcium deficiency or aluminum toxicity.

Table 1. General recommendations for the use of lime.

	To Take Care of Ca-Deficiency	**To Take Care of Al-toxicity**
Fine commercial lime (100% of particle <0.42 mm)	200 kg/ha or or 20 g/sq.m	2,000-5,000 kg/ha Lime or 200-500 g/sq.m
Fine coralline lime (30% of the particles <0.42 mm)	600 kg/ha or 60 g/sq.m	6,000-15,000 kg/ha or 0.6-1.5 kg/sq.m
Coarse coralline lime (few particles <0.42 mm; test b)	2,000 kg/ha or 200 g/sq.m	20,000-50,000 kg/ha or 2-5 kg/sq.m

What About The Yield Increase After Adding Lime?

Most soils in high rainfall areas of Western Samoa are acidic. However, only a few districts have very acid soils. These are to be found in the inland regions of Aleipata and Falealili, as well as Tiavi on the hill top. In these places, some of the soils have lost so much calcium and we need to add lime to restore it.

Crops like dwarf bean, peanut and sweet corn have shown good response to 500 kg fine coralline lime per ha in Togitogiga. A sensitive crop like dwarf bean did not grow at all in Togitogiga, unless lime was added. Peanut grew well in most places in Western Samoa. However, in one location the pods were almost empty, until coralline was added. Without lime, no good seeds were found in the pods. In the same location, liming increased the yield of sweet corn by 160%

In Fiji, the acid soils appear to have more of a problem with aluminum toxicity. A large number of crops appear not to grow at all in such soil types. However, pineapple and cassava can still grow in such very acid soils. More sensitive crops will need lime. Production is expected to be very low unless the aluminum toxicity is taken care of by adding lime (see table above).

Do not overlime and check soil pH regularly!!

N.B. There are two things to remember when trying to improve soil fertility using lime and fertilizer:

Do not overlime!!! This occurs when you add too much lime to the soil. This will increase the pH of the soil too much. Our aim is to keep pH of the soil around 6.0-6.5. There are many bad effects as a result of increased pH.

Test for pH regularly if you use a lot of fertilizer on your land!! When a field is fertilized every year, especially with commercial nitrogen fertilizers, the soil pH can decrease rather quickly. A soil test on such fields should be repeated at least once in every five years to check whether the pH is decreasing rapidly due to fertilizer application.

Definition of terms

acid soil	=soils with low pH
alkali soils	=soils with high pH
aluminum	=toxic element (Al)
calcium	=element needed for good plant growth (Ca)
clay	=a fine (sometime sticky) kind of soil
cmol(+) per kg	=unit for soil nutrients
deficiency	=when something is lacking, availability not enough
dissolve	=go into water (or other liquid)
fertilizer	=plant food added to soil two kinds:
organic fertilizer	=fertilizer made from plant/animal material
chemical fertilizer	=fertilizer prepared in a factory
lime	=a kind of fertilizer use to increase soil pH;
coralline lime	=lime from coral reef
dolomite lime	=lime with Ca as well as Mg
magnesium	=element needed for good plant growth (Mg)
nitrogen	=element needed for good plant growth (N)
nutrient	=plant food, minerals found in the soil
micronutrient	=nutrient required in small amounts
particle	=small pieces of material
pH	=measurement of soil acidity
phosphorus	=element needed for good plant growth (P)
potassium	=element needed for good plant growth (K)
sand	=coarse particles in soil
soil acidity	=how acid a soil is
soil fertility	=how rich a soil is in providing plant food, how many nutrients are in a soil;
fertile soil	=a soil with sufficient nutrients for good plant growth
infertile	=a soil with not enough nutrients
sulphur	=element needed for good plant growth (S)
toxic	=poisonous
toxicity	=when a mineral element becomes available in large quantities and harmful to plants

Recommended soil pH for some vegetable and fruit crops

Asparagus	6.0–8.0	Onions	6.0–7.0
Beans, lima	6.0–7.0	Peas	6.0–7.5
pole	6.0–7.5	Peppers	5.5–7.0
Broccoli	6.0–7.0	Pumpkin	5.5–7.5
Brussels sprouts	6.0–7.5	Radishes	6.0–7.0
Cabbage	6.0–7.5	Rhubarb	5.5–7.0
Cantaloupe	6.0–7.5	Spinach	6.0–7.5
Carrots	5.5–7.0	Squash, crookneck	6.0–7.5
Cauliflower	5.5–7.5	Strawberries	5.0–6.5
Celery	5.8–7.0	Swiss chard	6.0–7.5
Cowpeas	5.0–6.5	Tomatoes	5.5–7.5
Cucumbers	5.5–7.0	Turnips	5.5–6.8
Eggplant	5.5–6.5	Watermelon	5.5–6.5
Lettuce	6.0–7.0		

Time of application

In general....