Soil pH Reduction

Introduction

At the rates that Sulphur is applied for nutritional purposes, the effect on soil pH would be negligible. However, in certain circumstances, it is beneficial to lower the pH of soil**.** Common reasons for doing so include establishing heather and reducing common scab in potatoes.

Use of Sulphur on Over-limed/ Naturally Alkaline Soil:

Nutrient deficiency is common on neutral soils, alkaline soils or soils with excessive lime. Availability of essential nutrients is often lower due to the high pH of these soils. Temporary rectification of these issues can be achieved by foliar applications. However, on small areas of land where crop production is intensive, it is the more practical, permanent and advisable solution to reduce the pH of the soil, especially if it does not require significant lowering. An acid-forming compound can be used to achieve this, although applying elemental sulphur, such as Sovereign, is common. Where the level of acidifying material required to neutralise the soil is too high, elemental sulphur can be applied in bands.

Figure 1 - Elemental sulphur required to achieve a pH of approximately 6.5 for a depth of (7inches) on soil that is carbonate-free

	Broadcast application kg/h		**Furrow/band application kg/h**	
Soil pH	Sandy Soil	Clay Soil	Sandy Soil	Clay Soil
7.5	727-1090	1454-1818	364-456	545-909
8.0	1818-2727	2727-3636	545-909	1090-1454
8.5	2727-3636	3636 +	909-1454	1454 +
9.0	3636-5454		1454 +	

Alkali Soil

Alkali Soil Characteristics

- pH generally above 8.5
- Sodium in excess (>10% of total exchangeable cations)
- Physical properties of the soil (i.e soil tilth) are undesirable
- Conductivity is generally <1.5-3 mmhos/cm

Alkali Soil Development

- If the irrigation water contains excess sodium, an exchangeable sodium level of more than 10% could be caused.
- Alkali soil can often be caused as a result of improvements to a saline-alkali soil. When the water table is lowered and leaching occurs, salts that are dissolved in the drainage water are then removed. Due to the fact that sodium is attached to the soil colloids, it remains to disperse the soil. This soil becomes puddled, unable to absorb neither water nor air, sticky, greasy when wet and hard when dry. The pH sodium disperses organic matter which causes a black/brown colouring. Soils that are considered highly alkali are often capable of dissolving plant roots.

Reclaiming Alkali Soils

- It is important to create at least 3ft of drainage
- Chemical adjustment material should then be added and leached with good quality water.
- In calcareous soils, use elemental sulphur. This will acidify the soils which will dissolve calcium, replacing sodium from the exchange complex. The added water leaches the replaced sodium sulphate from the soil.

Water is often prevented from entering the soil properly if the soil is alkaline, sodium-saturated or in a particularly dispersed condition. Alkali soils have a pH of 7.0 or above. When the pH reaches 8.4, it could be assumed that sodium in excess has made the soil Alkali. Sub-optimum growth will occur in these soils and it is also possible that the crops will adopt salt toxicity.

Soils with a pH between 7.0 and 8.4 are very likely to contain an excess of Calcium Carbonate (lime). A high lime value means that the number of anions, such as phosphorous, will be decreased. Where high levels of sodium occur, soils can crust.

Another issue with soils with a high sodium value is that of compaction. This causes a problem because the degree of aeration is reduced when the pore sizes in the root zone are reduced; air cannot circulate through the water as easily. Therefore, the absorption of nutrients and root growth will be negatively affected. This type of soil is deemed to be 'deflocculated'.

Saline-Alkali Soil

A soil amendment that will initiate the exchange and consequent removal of excess sodium is required. Many products can be used for reclamation purposes such as these – most often used are calcium and iron as they are cations. More specifically, Gypsum (CaSo4) is used the most widely for adjusting alkali soil. Gypsum is capable of releasing soluble calcium that will replace the exchangeable sodium, despite the fact that it is comparatively insoluble in many situations. Lime ($CaCO_3$) is undesirable for use in soil reclamation because once a pH of 7 is reached, it becomes very insoluble. Soils below 6.0 pH are suitable for use of agricultural lime. If there is surplus free lime ($CaCO_3$), Sovereign Sulphur is advisable for amendment purposes as the elemental sulphur will convert to sulphuric acid as a result of the chemical breakdown through oxidation. Once this occurs, the sulphuric acid will react with the natural lime in the soil to form Gypsum. Elemental sulphur will be a fraction slower than gypsum as it requires oxidation before turning to sulphuric acid. However, Sovereign Sulphur's faster breakdown and quicker conversion of sulphur to Sulphate, which in turn causes a quicker conversion to sulphuric acid, means that it is an extremely effective soil amendment in soils where there is more than 1% free lime. The efficiency of the product and therefore the small amounts required in comparison to other methods means that haulage and application costs are often significantly lower. The table below displays equivalent amounts of Sovereign Sulphur required when compared to other soil amendments.

Figure 2

pH Reduction Method	**Equivalent Amounts**
Sovereign Sulphur	1000
Gypsum	5400
Ammonium Sulphate	4120

Saline-Alkali Soil Characteristics

- pH generally below 8.5 (neutral and acidic salt counterbalance the alkaline sodium salts preventing a high pH)
- Sodium and salts in excess
- Physical properties of the soil (i.e soil tilth/conditions) are generally good - (although Sodium may be present, the excess of salts maintains good soil condition)
- Conductivity is generally >1.5-3 mmhos/cm
- Higher than 10% exchangeable sodium

Reasons for Saline-Alkali Soil Development

- High salt and sodium levels in irrigation water
- High water tables

Reclaiming Saline-Alkali Soil

- It is important to create at least 3ft of drainage
- For non-calcareous soils, add gypsum
- For calcareous soils, add Sovereign Sulphur
- Ample time must be allow for the oxidation of Sulphur to sulphuric acid/ the dissolving of gypsum
- Leach sodium with water (see below for water rates)

Using Sulphur for Soil Reclamation

Saline /Alkali Soils are saturated with sodium in a dispersed condition, making it extremely difficult, if not impossible, for water to enter the soil. Soil saturated with calcium is in a flocculated condition, making water penetration and movement easy.

As a result, in order to reclaim Alkali or Sodic soil, calcium is required to replace any excess sodium on the cation exchange complex. This can be achieved by applying gypsum or other soluble calcium salt onto the soil directly. Once this process is complete, the sodium must then be extracted from the rooting zone. This can be achieved by leaching sodium sulphate from the root zone through water.

Crusting and Compaction of Soils

It is not uncommon for both saline-alkali and alkali soils to show signs of crusting and soil compaction. The results of these issues often become obvious in the crops; in particular, a lack of phosphorus/micronutrients can be particularly noticeable.

Reasons for soil crusting

- High Na (sodium) levels
- Pulverised dry soils (reduced to fine particles)
- Heavy water application
- Low OM soils
- Water high in sodium and bicarbonates

Solutions to soil crusting

- Ensure soil is tilled at a good moisture level
- Use elemental Sulphur
- Use fertilisers that form acid
- Humic acid

The principal cause of soil crusting is classically a high pH reading. If one is to lower the pH, the quality of the soil conditions will be increased. In order to do this, free lime must be present in the soils intended for amendment. When the pH is lowered, the calcium obtained from the free lime will adhere to the clay colloid. For good flocculation of the soil, there must be more than 20PPM calcium present.

Sulphur products as soil amendments

Sulphuric acid is released as Sovereign Sulphur breaks down from elemental Sulphur (S) to plant-useable Sulphate (SO3). This acid will react with the free lime present to create gypsum and carbonic acid. This gypsum created as a result of Sovereign's oxidation process will aid the flocculation of the soil.

Soil Flocculation occurs when the Calcium from the gypsum and the clay colloid interacting in a cation exchange reaction where the positively charged calcium ions will stick to the negatively charged clay colloid. This allows for better soil tilth and thus, less soil crusting.

Sovereign can also benefit soil in other ways: the salting issues linked to calcareous soils are often reduced with applications of Sovereign Sulphur. Calcium will kickoff sodium from the clay colloid and into the soil solution where it is leachable.

STEPS INVOLVED IN USING SOVEREIGN AS A SOIL AMENDMENT

1 – Sovereign Sulphur + O^2 + H^20 -------- Sulphuric Acid

2 - Sulphuric Acid + Free Lime --------Gypsum + CO^2 +H^2O

3 – Gypsum + Sodic soil ----------Calcium soil + sodium sulphate

Benefits of using Sovereign Sulphur

- Release of micronutrients/Phosphate
- Formation of gypsum
- Reduction of crusting
- Water penetration speed increase
- Water run off speed increase
- Removal of sodium
- Aeration of soil improves

Summary

Soil amendment is the addition of a material to the soil in order to adjust and improve the properties of the treated soil, consequently improving plant growth. The recommendations and discussion points above outline ways in which one can utilise Sovereign Sulphur as a soil amendment tool as well as ways in which it is superior to other methods of amendments.

Sovereign can be used to adjust soil pH and tilth – the soil can be flocculated through the release of calcium into the soil following the conversion of free lime present in most soils into gypsum. This means that the calcium is switched to sodium on the clay colloid.

Saline-alkali and alkali are recognised by sodium on the soil particle as opposed to calcium and magnesium. It is more than possible that there could be an excess of soluble salts in the soil. While the percentage of absorbed sodium augments, an alkali soil is likely to become dispersed as well as impermeable to water and air. Too much sodium is toxic to the crop.

Sulphur compounds such as Sovereign Sulphur can be used on soils in order to provide calcium or release calcium that was previously insoluble. This calcium replaces the absorbed sodium on the colloid. The sodium then combines with the sulphate ion to form a soluble sulphate which will be removed through leaching of the soil.

By using this product for soil amendment, nutrients will be more widely available to aid the growth of plants. Crop yield, quality and profitability of the plants will be increased as a result.

Kilos of sulphur required per hectare to lower the soil pH of one hectare to a depth of 12cm

Kg of Sulphur required per hectare			
Change in pH	Sand	Loam	Clay
8.5 – 6.5	3818	4773	5727
8.0 – 6.5	2673	2864	3818
7.5 – 6.5	955	636	1909
7.0 – 6.5	191	300	573

Source: John P. Taberna. Soil Scientist, Parma Idaho