

# Soil Aluminum

Aluminum is one of the most abundant elements in soil, making up nearly seven percent of the earth’s crust. It is also one of the two structural elements in most clays. High concentration of soil aluminum limits crop production in many acidic soils around the world and is particularly a problem in tropical soils. But there are different forms of aluminum. The dissolved form in soil solution is toxic to plants at low concentrations, causing root stunting and reducing water and nutrient uptake. This soluble form of aluminum ( $Al^{+3}$ ), however, does not come into solution unless the soil pH is 5.5 or below becoming a likely cause of toxicity problems below pH 5.0.

Solubility of soil Al increases with increasing acidity (lower pH values) changing from hydroxy-aluminum ( $Al(OH)^{+2}$  and  $Al(OH)_2^+$ ), to the soluble  $Al^{+3}$  form between pH 5.5 and 4.5.

Figure 1. Forms of aluminum in solution change with pH.

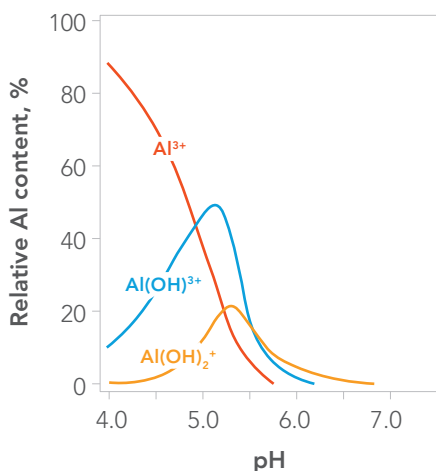


Table 1. Concentration of Al in soil using CsCl extracting solution.

	Exchangeable Al, ppm	Exchangeable Al, meq/100 g	Effect on plant growth
Low	0 - 5	0 – 0.06	No negative effect on most plants
Medium	5 - 10	0.06 – 0.11	Slightly limiting effect on roots – lime soil to correct the pH
High	10 – 25	0.11 – 0.278	Increasing toxic effects on plants – lime soil or grow acid tolerant crops
Very High	>25	>0.278	Highly toxic effects on plants – grow acid tolerant crops and/or begin liming program
Extremely High	>250	>2.78	Ameliorate soil with lime and organic material to reduce aluminum solubility

In general, for soils with a silt loam, loam, clay loam or clay texture:

- pH below 5.0, soluble aluminum is almost certain to be a problem
- pH between 5.0 and 5.5, soluble aluminum may be a problem
- pH between 5.5 and 6.0, soluble aluminum is not likely to be a problem
- pH above 6.0, soluble aluminum is almost certainly not a problem.

Extractable aluminum is normally less than 5 ppm when soils have pH>7.0. When soils become acidic, soil aluminum becomes increasingly more soluble. Soils with pH<5.5 can have aluminum levels high enough to cause reduced root growth for most crops. A salt solution (KCl,  $CaCl_2$  or CsCl, etc.) is used in extracting aluminum from the soil sample. Typical ranges for a soil with pH <5.9 is 15 – 25 ppm.

Correcting a slightly acidic soil to reduce soluble aluminum is easily accomplished with a lime application. Soil with a pH between 5.5 and 6.0 can be brought

to a pH of 6.5 with an application of agricultural lime according to soil sample results and recommendations. If the pH is below 5.5 it may take several lime applications over a few years to raise the pH to 6.5.

Alternatively, several crops such as blueberries, cranberries and many ornamental plants tolerate or even thrive in low pH soil. If soluble aluminum is very high, the soil can also be ameliorated with an application of compost or other organic matter that will remove the aluminum from soil solution. Plants growing in soil with a high organic matter content can tolerate higher amounts of soluble aluminum because the organic material forms complex compounds with the aluminum that are not absorbed by the plants.

Aluminum and hydroxy-aluminum also remove phosphorus from the soil solution, making applications of phosphate fertilizer less effective when the soil pH is 5.5 and below - this is another reason to add lime to the soil to bring the pH to 6.5.