Acidification in Horticultural Systems

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Introduction

Soil acidification is a natural process that has become a serious land degradation issue through agricultural practice. Acid soils limit the choice of crops and pastures that can provide an economic return. Growers have fewer options to manage other land degradation issues such as compaction, shallow water tables and erosion.

What is Acidity?

Acidity is due to the presence of hydrogen ions in soil. Ions are charged particles. The hydrogen ion has a positive charge and is represented by the symbol H+.

The pH is a measure of the concentration of H+ in a solution. The pH scale ranges from 1 to 14. Each unit change in pH is a **10-fold change** in acidity. Neutral soil has pH 7 and acid soil has a pH below 7. Most plants grow between pHCa 5 and 8.

Acidic soil pH_{Ca}<5.5: Over time, acidity can move down from acid topsoil to the subsoil where it becomes more difficult to manage. Sensitive plants may become impacted by higher availability of manganese (Mn) in certain soil types. Affected plants tend to crinkle and cup.

Strongly acidic soil pH_{Ca}<4.8: Effects of aluminium (Al) tend to dominate over those of Mn. Soluble Al can enter roots passively and damage their growth. Affected plants are unable to take up sufficient water and nutrients from soil for shoot growth, reducing yield and quality.

Very low pH can also lead to deficiencies in calcium, magnesium and potassium due to leaching, and molybdenum and phosphorus due to reduced availability. Microbial populations and worms are also impacted, affecting nutrient cycling, nodulation of legumes and nitrification of ammonium to nitrate. There is less dry matter production and surface cover, increasing the risk of wind and water erosion.

Very strongly acidic soil pH_{Ca}<4: The acidity begins to break down the soil minerals and organic matter causing permanent structural decline. Serious nutrition problems are likely. Plants are surviving rather than producing.

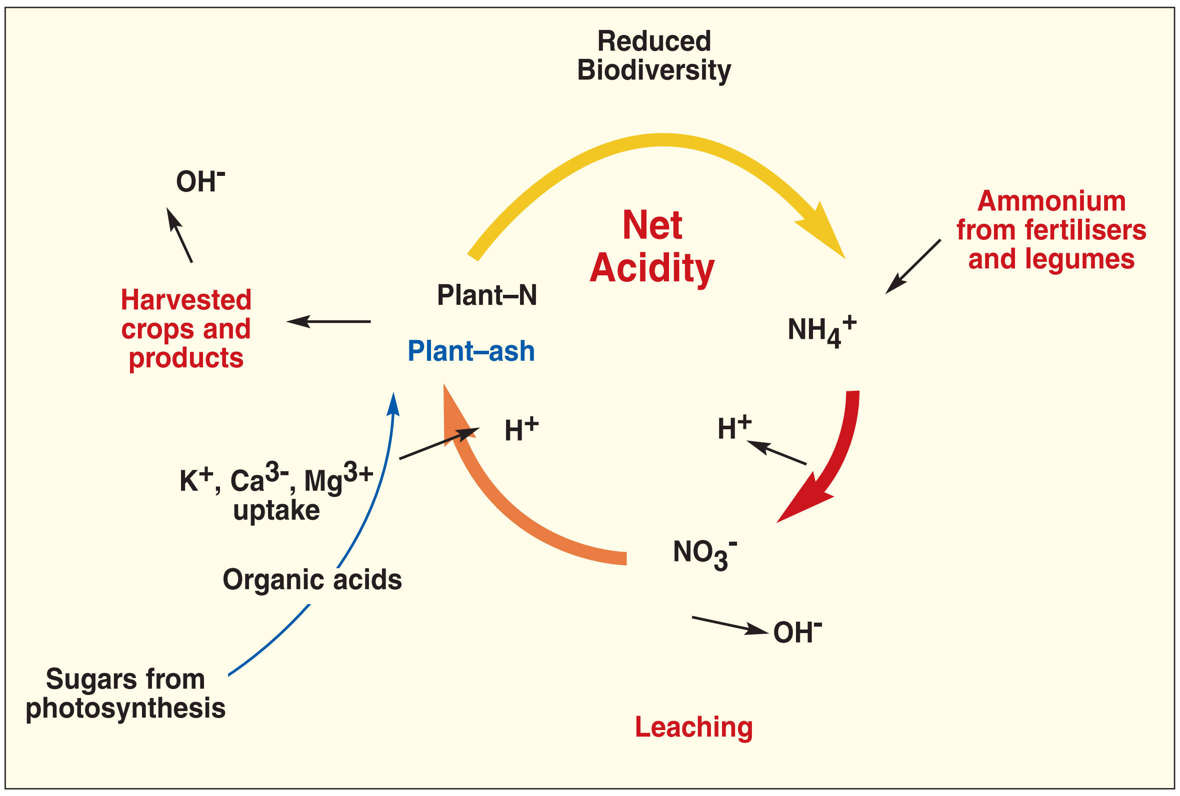
Measuring Soil pH

Laboratories measure pH in either water pHw or calcium chloride solution pH_{Ca} using a ratio of 1 part soil to 5 parts solution. Soil pH measured in water is a better reflection of pH that roots are exposed to, but is subject to seasonal variation. Use of calcium chloride solution largely overcomes the seasonal variation in pH allowing samples taken at different times of the year to be compared.

Results of soil tests are as good as the sample taken hence instructions need to be followed when taking samples, returning to the same general area each time. Field test kits and pH meters can be used to check soil pH.

Agricultural Practices Promoting Acidity

The major sources of acidification attributed to agricultural practice are linked to management of the nitrogen and carbon cycles (**Figure 1**). Gaining a better appreciation of the linkages allow risk factors to be more readily identified and targeted by management.



▲ **Figure 1:** Acidification in agricultural systems.
Source: J Chapman

1. Increasing the source of H⁺ through use of ammonium fertilisers and growing legumes.
Acidity is released into the soil solution when bacteria convert ammonium NH_4^+ to nitrate NO_3^-. The process is very rapid, which sets up the potential for acidification. In natural systems, the acidity is neutralised when plants take up nitrate and when the organic –N is eventually mineralised back into ammonium.

2. Nitrate Leaching
Nitrate produced from ammonium releases H+ the soil solution. Plants **must** uptake the NO_3^- to release the agent responsible for removing H^+ from the soil solution. The neutralising potential is lost once NO_3^- is leached past the active root zone. For a given concentration of NO_3^- leached, an equivalent concentration of H^+ is left behind in the soil solution.

Due to its negative charge, NO3- is not held by soil particles. Nitrate is highly soluble in water and will readily move in soil with the passage of the water front following rainfall. Due to these reasons some ammonium derived nitrate will naturally leach, particularly in regions with high winter dominant rainfall. However, agricultural practice promoting NO_3^- leaching can rapidly acidify soil.

The release of H^+ into the soil solution is avoided when NO_3^- is applied as fertiliser. Consequently leaching of fertiliser nitrate will not in itself contribute to acidification. However uptake of fertiliser nitrate can "mop up" some of the acidity produced from other sources, thus leaching should be avoided.

3. Harvest or export of crops or plant products
N-Cycle: Harvested legume products – hay or seed, which are high in organic-N, will remove some of the neutralising potential, leading to acidification.

C-Cycle: Plants take up more positively charged nutrient cations (e.g. potassium, calcium, and magnesium) than negatively charged nutrients (e.g. NO_3^- and phosphate). To maintain neutral charge plants release H^+ into the soil solution. The amount of H^+ released equals the amount of excess positive charge resulting from the uptake of cations.

Many plants source the H^+ from organic acids converted from sugars produced by photosynthesis. As with the nitrogen cycle, the acidity is neutralised when plant remains are mineralised and the excess nutrient cations are returned to the soil.

When plant products and crops are harvested, or exported from one paddock or another through animal grazing or movement of cut hay, the stored alkalinity or plant ash cannot be returned, leaving the excess H^+ to acidify the soil.