

Basic Foliar Nutrient Chemistry

Although this part of the learning curve may seem simplistic to some, it is useful to study and understand to get the full benefit out of the entire Bio-Gro product line. This portion of the manual will help illustrate the basic chemistry of trace minerals needed to get the most out of every dollar spent by your customers.

If you do not fully understand this basic chemistry, it is highly recommended that you first study the information presented in “BG CFS – Basic Fertilizer Chemistry”.

Foliar nutrition is a rapidly developing form of plant nutrient supplementation. Most foliar applications of N-P-K-S and minerals applied “piggyback” with chemicals used for weed control and/or plant protection agents.

To record all the available ratios and blends of nutrients would require publishing a book, too large for one person to carry. The purpose of this publication is to assist the reader in getting right down to the basics and realizing that most foliar fertilizer blends are derived from similar ingredients and that there are really no secrets.

Basic Foliar Ingredients:

Nutrient:	Common Sources:
Nitrogen	Urea, ammonium hydroxide and nitric acid
Phosphorus	Phosphoric acid
Potassium	Potassium chloride, nitrate, sulfate, carbonate and hydroxide
Sulfur	Sulfuric acid
Calcium	Nitric and hydrochloric acid solublized calcium
Magnesium	Sulfuric, nitric and hydrochloric acid solublized magnesium
Iron	Sulfuric, nitric and hydrochloric acid solublized iron
Zinc	Sulfuric, nitric and hydrochloric acid solublized zinc
Manganese	Sulfuric, nitric and hydrochloric acid solublized manganese
Copper	Sulfuric, nitric and hydrochloric acid solublized copper
Boron	Sodium tetraborate and boric acid

The basic ingredients from the table above are available in various grades. Grading basic ingredients is simply based on the purity of the ingredient in regards to contaminants such as micronutrients and heavy metals. For example, “white” phosphoric acid and “merchant” or “green” phosphoric acid is still just phosphoric acid; the difference is that white acid has little or no contaminants.

These basic ingredients are also further blended and processed into common ingredients found on product labels such as ammonium nitrate, monoammonium phosphate, etc. Yet, no matter how they are processed, blended, combined and labeled, they still perform the same simple function: **provide water-soluble nutrients for plant growth!**

To obtain maximum water solubility is the first goal of foliar applications. Take for example, the micronutrient zinc; in its raw mined state it is a rock. For agricultural purposes it is combined with acid based chemicals such as nitric, sulfuric, hydrochloric and sometimes phosphoric acids to obtain water solubility. In a spray tank one must maintain a high concentration of hydrogen ions (acid) to keep it in a water-soluble form. For foliars this is extremely important! If the finished foliar mix is even cloudy this indicates that one, or more, of the nutrients has become insoluble.

The following table is helpful to study, because in the macro and micro minerals, there are some basic rules of solubility that must be followed. Note that there are dozens of other forms of each mineral that could be recorded, but these are important in agriculture:

Nutrient	Soluble form as:	Insoluble form as:
Calcium	nitrate, chloride & phosphate	oxide, hydroxide & sulfate
Zinc	nitrate, chloride, sulfate & phosphate	oxide, carbonate & hydroxide
Magnesium	nitrate, chloride, sulfate & phosphate	oxide, carbonate & hydroxide
Manganese	nitrate, chloride, sulfate & phosphate	oxide & carbonate
Copper	nitrate, chloride, sulfate & phosphate	oxide, carbonate & hydroxide
Iron	nitrate, chloride, sulfate & phosphate	oxide, carbonate & hydroxide

Except for calcium, the base rule that applies to the above table is that minerals are soluble in an acid (H) environment (pH less than 7.0) and insoluble in a basic (OH) environment (pH higher than 7.0). Calcium is also very dependent on acidity to remain in a water-soluble form, but becomes an insoluble compound with sulfate at even an extremely acid pH. **Therefore, you should not use sulfated minerals such as zinc sulfate, etc., with calcium fertilizers such as calcium nitrate.**

Highlight Note:

Ever wonder why mixing calcium chloride (or nitrate) with water-soluble N-P-K blends that contain sulfated minerals such as zinc, potassium, copper and iron (example: Water Soluble 10-45-10) cloud up and settle out in the spray tank, especially when it stands over night? If the pH is low enough, only calcium sulfates are formed. At higher pH (4.5 & up) calcium phosphates can be formed also.

pH – An Important Aspect

Before one can fully appreciate complex subject of chelating agents and their effect on the solubility of minerals, let us look at another item of important information. Some may be wondering why the common minerals in the table on the preceding page are listed as soluble with phosphates. Especially if they have attempted to mix a hot mix N-P-K blend such as liquid 3-18-18 with minerals, it is definitely not soluble.

This solubility is related to the final pH of the spray solution. However, before we explain this, you must first understand the pH scale. Therefore we will cover this topic in greater detail before explaining the significance of the pH of your spray solution and the mixes you can make by fully understanding this important factor. The pH value of a solution (a spray tank full of water and fertilizer) is directly related to the ratio of the hydrogen ion (H⁺) and the hydroxyl ion (OH⁻) concentrations. If the H⁺ concentration is greater than OH⁻, the material is acidic; (pH value is **less** than 7.0). If the OH⁻ concentration is greater than H⁺, the material is basic, (pH value **greater** than 7.0) If equal amounts of H⁺ and OH⁻ ions are present, the material is neutral, (pH of 7.0).

Acids (phosphoric acid - H₃PO₄) and bases (potassium hydroxide - KOH) have free hydrogen and hydroxyl ions, respectively. Since pH is a logarithmic function, a change of one pH unit represents a ten-fold change in hydrogen ion and hydroxyl ion concentration. The following table can best sum up this expensive words “logarithmic function”. You will notice that with a change in each pH “point “ both acidic and basic ion concentration are 10 times higher than the one it follows, or precedes:

Number of H ⁺ ions	per	Number of OH ⁻ ions
10,000,000,000,000 H ⁺ ions	pH 1.0	10 OH ⁻ ions
1,000,000,000,000 H ⁺ ions	pH 2.0	100 OH ⁻ ions
100,000,000,000 H ⁺ ions	pH 3.0	1,000 OH ⁻ ions
10,000,000,000 H ⁺ ions	pH 4.0	10,000 OH ⁻ ions
1,000,000,000 H ⁺ ions	pH 5.0	100,000 OH ⁻ ions
100,000,000 H ⁺ ions	pH 6.0	1,000,000 OH ⁻ ions
10,000,000 H ⁺ ions	pH 7.0	10,000,000 OH ⁻ ions
1,000,000 H ⁺ ions	pH 8.0	100,000,000 OH ⁻ ions
100,000 H ⁺ ions	pH 9.0	1,000,000,000 OH ⁻ ions
10,000 H ⁺ ions	pH 10.0	10,000,000,000 OH ⁻ ions
1,000 H ⁺ ions	pH 11.0	100,000,000,000 OH ⁻ ions
100 H ⁺ ions	pH 12.0	1,000,000,000,000 OH ⁻ ions
10 H ⁺ ions	pH 13.0	10,000,000,000,000 OH ⁻ ions
1 H ⁺ ion	pH 14.0	100,000,000,000,000 OH ⁻ ions

As we have stated, pH is an indicator of the **RATIO** of H⁺ to OH⁻, not the amount of one or the other. The **AMOUNT** of one or the other is the **pH BUFFERING** capacity of the solution. For example, let us say that we have 3 gallons of pure water that has 10

million H⁺ ions and 10 million OH⁻ ions; they are balanced, so the pH is 7.0. To lower the pH of this solution to pH 6.0, you would have to add 99 million H⁺ ions.

Now let us say that you took 9 gallons of this same water and filtered out 6 gallons of pure water. You would have 3 gallons of water, but now there are 30 million of each H⁺ and OH⁻ in the water. The RATIO of H⁺ ions to OH⁻ ions is still balanced; therefore, the pH is still 7.0. However, now in order to lower the pH down to 6.0, you would have to add a higher AMOUNT of H⁺ ions, 297 million. Therefore, the second 3 gallons has a higher BUFFERING capacity.

In the table below, a tank mix of 2 gallons per acre of 3-18-18 was mixed with 8 gallons of water and a quart per acre rate of each mineral added separately. The minerals used were: 10% calcium nitrate and 5% solutions of manganese, zinc, iron and copper sulfates and 4% magnesium sulfate.

The 3-18-18 was added to the water first and then the mineral was added. All the minerals reacted with the phosphate in 3-18-18 and became insoluble mineral phosphates. The mixture was stirred while slowly adding straight white phosphoric acid (75%) (lots of hydrogen ions - H⁺) until the solution cleared up. The pH was taken and recorded as the first number below. Then while still stirring, potassium hydroxide (45%) (lots of hydroxyl ions - OH⁻) was added to raise the pH until precipitate began to form again which is the second pH number:

Mineral	pH Range for Complete Water-Solubility	Mineral	pH Range for Complete Water-Solubility
Calcium	2.20 to 3.60	Manganese	3.90 to 4.60
Magnesium	3.50 to 6.60	Iron	2.70 to 4.00
Zinc	3.50 to 3.70	Copper	3.95 to 4.00

In summary, if mixing straight nutrient solutions all of the above minerals can be mixed with N-P-K in a tank and remain soluble if the pH for each mineral is maintained as above.

Highlight Note:

The above table is published here to demonstrate the pH range you need to maintain phosphate and respective mineral combinations in clear solutions, without any chelating agents, with no visual precipitate. However, some of these pH ranges are very DANGEROUS to spray on some crops. For example, zinc can become very phytotoxic to some plants, or plant parts, when sprayed on at pH ranges below 5.0, especially if poor drying conditions exist. Always be sure you KNOW what you are doing before you spray low pH mineral solutions.