AGGRAND®

Soil Fertility Guide

Organic Matter

Organic matter (OM) supplies many plant nutrients and the carbon necessary for the proliferation of all living things. Carbon stimulates the proliferation of microbes (fungi, bacteria, actinomycetes and algae), earthworms and other beneficial creatures that live in the soil.

Microbes secrete organic acids that release nutrients from soil particles by etching their surfaces, and they also secrete polysaccharides that glue soil particles into stable aggregates. The end result of prolific microbial activity is improved soil structure and air penetration.

It is necessary to supply organic matter regularly to optimize growth of microbes, soil creatures and plants. Use of cover crops, return of crop residue, addition of compost and/or composted manure and practices that maintain organic matter on the surface of the soil all increase organic matter levels.

Application of AGGRAND Natural Fertilizer 4-3-3 stimulates microbial and earthworm activity by supplying carbon and a balanced array of other nutrients. It also contains concentrated humus and other synergistic compounds that release nutrients and chelate other nutrients, making them available for microbial growth and plant uptake. Soil applications of AGGRAND Natural Fertilizer in spring and fall are beneficial in promoting the processes that break down organic matter into humus and make nutrients available.

Soil Test Levels

_____Less than 2%: Apply organic matter 2-3 times per year and apply one quart of AGGRAND Natural Fertilizer/2,000 sq. ft. (5 gals./ac.) 2-3 times per year. Till in with the organic matter, crop residue or cover crops.

_____2-3%: Apply organic matter 1-2 times per year and apply one quart of AGGRAND Natural Fertilizer/3,000 sq. ft. (3 gals./ac.) 1-2 times per year. Till in with organic matter, crop residue or cover crops.

_____3-10%: Adequate amount present. Apply organic matter once per year and apply one quart of AGGRAND Natural Fertilizer/3,000 sq. ft. (3 gals./ac.) once per year. Till in with organic matter, crop residue or cover crops.

Rates of Organic Matter to Apply

New Plantings

_____First year: (establishment of a new garden, lawn, orchard, etc.) 2″ deep, 6.5 cu.yds./1,000 sq. ft. (270 cu.yds/ac.).

Gardens and Vegetable Crops

_____Less than 2%: 1″ deep, 3.3 yds./1,000 sq. ft. (135 cu.yds./ac.).

_____2-3%: ½″ deep, 1.5 yds./1,000 sq. ft. (68 cu.yds./ac.).

_____Over 3%: ¼″ deep, 0.75 yds./1,000 sq. ft. (34 cu.yds./ac.).

Orchards and Vineyards

_____Less than 2%: 1-2 cu. ft./tree or vine (6-8 cu.yds./ac.) for mature plants.

_____2-3%: 0.5-1 cu. ft./tree or vine (46 cu.yds./ac.) for mature plants.

_____Over 3%: 0.25-0.5 cu. ft./tree or vine (2-3 cu.yds./ac.) for mature plants.

Phosphorus

Phosphorus (P) is the powerbroker; the ATP (adenosine triphosphate) molecule releases the energy required for plant growth when it is reduced to ADP (adenosine diphosphate) in the root cells where respiration takes place. Phosphorus controls root, seed and flower development, as well as the processes of cell division and sugar formation. Sugar levels regulate the plant's susceptibility to insect and disease attack and determine fruit quality and shelf life. Phosphorus also regulates nitrogen fixation in the root nodules of legumes.

The laboratory measures phosphorus in two ways: P1 (weak bray) and P2 (strong bray) is unavailable phosphorus which is converted to the available form through microbial breakdown. Available phosphorus levels can be very low at planting time when the soil is still cold and wet, but the levels increase as microbial activity, soil temperature and drying of the soil increase. Increasing the soil organic matter level increases phosphorus availability; pH also affects phosphorus availability. The optimum pH for phosphorus availability is 6.0-6.5. If the pH is outside this range, supplementary phosphorus may be needed even if soil tests show adequate P1. Before it is released through microbial activity, phosphorus banded in the row at planting aids in early plant growth and development.

Phosphorus Fertilization

Low soil test levels dictate the need to add phosphorus to the soil profile, which can be accomplished with the addition of soft rock phosphate or bonemeal once every 2-3 years. When used in conjunction with the application of organic matter and planting of legumes, phosphorus becomes more plant available.

AGGRAND Liquid Bonemeal 0-12-0 and AGGRAND Natural Fertilizer supply phosphorus, and are most effective when banded at planting and during early development and the prebloom stage of foliar applications. Water in transplants or apply by dribbling them into a trench below and to the side of the seed at planting. For foliar applications, apply AGGRAND Natural Fertilizer when plants are 3-6″ tall; apply as a fine mist with enough fertilizer to cover the leaves. To stimulate prolific flowering, add AGGRAND Liquid Bonemeal as a fine mist. For fruit production, use AGGRAND Natural Fertilizer in place of Liquid Bonemeal. Some crops are sensitive to nitrogen applied at this stage, which may inhibit flowering and reduce fruit quality (apples are especially sensitive). On these crops, it may be beneficial to substitute AGGRAND Natural Kelp and Sulfate of Potash 0-0-8.

Soil Test Levels

P1

Most vegetables and flowers

_____Below 20 ppm: Apply 50 lbs./1,000 sq. ft. (2,000 lbs./acre) of colloidal phosphate every 2-3 years. Water in transplants or band 3 oz. of AGGRAND Natural Fertilizer and 2 oz. of Liquid Bonemeal per 20 ft. of row (3 gal./acre Natural Fertilizer and 2 gal./acre Liquid Bonemeal).

_____20-30 ppm: Apply 25 lbs./1,000 sq. ft. (1,000 lbs./acre) of colloidal phosphate every 2-3 years. Water in transplants or band 3 oz. of AGGRAND Natural Fertilizer and 1 oz. Liquid Bonemeal onto 20-30 ft. of row (3 gal. Natural Fertilizer and 1 gal. Liquid Bonemeal/acre).

_____30-50 ppm: Apply 12 lbs./1,000 sq. ft. (400 lbs./acre) of colloidal phosphate every 2-3 years. Water in transplants or band 3 oz. AGGRAND Natural Fertilizer onto 20-30 ft. of row (3 gal./acre).

_____Above 50 ppm: Water in transplants or band 3 oz. of AGGRAND Natural Fertilizer onto 20-30 ft. of row (3 gal./acre).

_____For grains, if below 20 ppm: Use same applications as 30-50 ppm under vegetables and flowers of colloidal phosphate every third spring and apply 1 qt. of AGGRAND Liquid Bonemeal/1,000 sq. ft. (6 gal./acre) every spring.

_____For lawns and pastures, if P1 is above 30 ppm: No additional phosphorus is needed except what is applied with standard AGGRAND Natural Fertilizer applications.

_____For tree fruits and grapes, if P1 is below 30 ppm: Apply 50 lbs./1,000 sq. ft. (2,000 lbs./acre) of colloidal phosphate every 2-3 years and apply 3 oz. of AGGRAND Natural Fertilizer and 2 oz. of AGGRAND Liquid Bonemeal/1,000 sq. ft. (3 gal. Natural Fertilizer and 2 gal. Liquid Bonemeal/acre) as a soil application in early spring or fall after harvest.

_____For tree fruits and grapes, if P1 is 30-40 ppm: Apply 25 lbs./1,000 sq. ft. (1,000 lbs./acre) of colloidal phosphate every 2-3 years and apply 3 oz. of AGGRAND Natural Fertilizer and 1 oz. of AGGRAND Liquid Bonemeal/1,000 sq. ft. (3 gal. Natural Fertilizer and 1 gal. Liquid Bonemeal/acre) as a soil application in early spring or fall after harvest.

_____For tree fruits and grapes, if P1 is 40-60 ppm: Apply 10 lbs./1,000 sq. ft. (400 lbs./acre) of colloidal phosphate every 2-3 years and apply 3 gal. AGGRAND Natural Fertilizer/1,000 sq. ft. or in the field apply 3 gal. AGGRAND Natural Fertilizer /acre as a soil application in early spring or fall after harvest.

_____For tree fruits and grapes, if P1 is above 60 ppm: No additional phosphorus is needed except what is applied with standard applications.

P2

_____For all crops, if P2 is below 60 ppm: Follow individual recommendations under P1.

_____For all crops, if P2 is above 60 ppm: No additional phosphorus is needed. AGGRAND Natural Fertilizer applications and the addition of organic matter will convert unavailable phosphorus into available form.

Potassium

Potassium (K) is the universal helper that flows throughout the plant, regulating osmotic balance, opening and closing of stomates and cell turgor pressure, while stimulating rooting, photosynthesis, chlorophyll formation, starch formation and translocation of sugars. Adequate potassium levels reduce plant susceptibility to insect and disease attack.

Potassium can become tightly held in the crystalline clay lattice of the soil. Loose non-compacted soils with adequate levels of organic matter are rarely low in available potassium. Practices that stimulate microbial activity, including addition of crop residue, cover cropping and broadcast applications of fish-kelp based fertilizers, release unavailable potassium.

Potassium Fertilization

Low soil test levels indicate the need for potassium fertilization, especially in soils with low cation exchange capacity (CEC) and low organic matter levels. The addition of wood ashes, sulfate of potash, kelp meal and composted manure increase soil potassium levels.

If soil cation exchange capacity and organic matter levels are low, follow recommendations for increasing organic matter levels to increase potassium availability and soil test levels. In addition to using potassium fertilizers and organic matter, applications of AGGRAND Natural Fertilizer also stimulate release of potassium. Follow application guidelines under soil organic matter for applying AGGRAND Natural Fertilizer to stimulate potassium release.

Banded applications of AGGRAND Natural Fertilizer and Natural Kelp and Sulfate of Potash supply potassium directly to the root zone. These fertilizers are banded in varying rates depending on potassium fertility and crop demands. Root crops and perennial crops require higher levels of potassium than other crops. To increase potassium availability during early growth and development, water in transplants or apply AGGRAND Natural Fertilizer by dribbling into a trench below and to the side of the seed at planting. The addition of AGGRAND Natural Kelp and Sulfate of Potash will further increase potassium availability. In the field, apply AGGRAND Natural Fertilizer as a band at planting, and add AGGRAND Natural Kelp and Sulfate of Potash to further increase potassium availability. Dilute with enough water to allow even flow rate and distribution when using liquid banding equipment (1:1/1:3 water/AGGRAND ratio is usually sufficient).

Foliar applications of AGGRAND Natural Fertilizer and AGGRAND Natural Kelp and Sulfate of Potash supply potassium directly through the leaves. Apply when plants are 3-6″ tall, at prebloom and again during fruit fill. Use the same rates as banded applications; dilute into a 1-4% solution with water, and apply as a fine mist with enough mixture to thoroughly cover the leaves.

Potassium Soil Test Levels

For most vegetables and crops

_____Below 100 ppm: Apply 15 lbs./1,000 sq. ft. (600 lbs./acre) of wood ash, 20 lbs./1,000 sq. ft. (800 lbs./acre) of kelp meal or 7 lbs./1,000 sq. ft. (300 lbs./acre) of sulfate of potash per year as a broadcast application. Water in transplants, or band 3 oz. AGGRAND Natural Fertilizer and 2 oz. AGGRAND Natural Kelp and Sulfate of Potash into 20 ft. of row (3 gal. Natural Fertilizer and 2 gal. Natural Kelp and Sulfate of Potash/acre) at planting. Foliar feed at the same rate when plants are 3-6″ tall, at prebloom and during fruit fill.

_____100-150 ppm: Apply 10 lbs./1,000 sq. ft. (400 lbs./acre) of wood ash, 13 lbs./1,000 sq. ft. (600 lbs./acre) of kelp meal or 5 lbs./1,000 sq. ft. (200 lbs./acre) of sulfate of potash per year as a broadcast application. Water in transplants or band 3 oz. AGGRAND Natural Fertilizer and 1 oz. AGGRAND Natural Kelp and Sulfate of Potash into 20 ft. of row (3 gal. Natural Fertilizer and 1 gal. Natural Kelp and Sulfate of Potash/acre) at planting. Foliar feed with the same mixture diluted at 1-4% with water when plants are 3-6″ tall, at prebloom and during fruit fill. Apply as a fine mist with enough solution to thoroughly cover the leaves.

_____150-250 ppm: Apply 5 lbs./1,000 sq. ft. (200 lbs./acre) of wood ash, 7 lbs./1,000 sq. ft. (300 lbs./acre) of kelp meal or 3 lbs./1,000 sq. ft. (120 lbs./acre) of sulfate of potash per year as a broadcast application. Water in transplants or band 3 oz. AGGRAND Natural Fertilizer into 20 ft. of row (3 gal. Natural Fertilizer/acre) at planting. Foliar feed at the same rate when plants are 3-6″ tall, at prebloom and during fruit fill. Apply as a fine mist with enough solution to thoroughly cover the leaves.

_____Above 250 ppm: Water in transplants or band 3 oz. AGGRAND Natural Fertilizer into 20-30 ft. of row (2-3 gal. Natural Fertilizer/acre) at planting. Foliar feed at the same rate when plants are 3-6″ tall, at prebloom and during fruit fill. Apply as a fine mist with enough solution to thoroughly cover the leaves.

For root crops, tubers and tree crops

_____250-350 ppm: Use same applications as 100-150 ppm in previous section (most crops).

_____250-350 ppm: Use same applications as 150-250 ppm in previous section (most crops).

_____Above 350 ppm: Use same applications as above 250 ppm in previous section (most crops).

Excess Potassium

_____Above 350 ppm: No ash, broadcast potassium or raw manure.

_____For most vegetables and crops, if potassium level is above 350 ppm, broadcast gypsum 2-4 times per season at 50 lbs./1,000 sq. ft. (1 ton/acre) and irrigate to remove excess potassium. Increase number of applications as potassium increases above 350 ppm.

_____For root crops, tubers and tree crops, if potassium level is above 450 ppm, use same gypsum application rates as for most crops.

Magnesium

Magnesium (Mg) is considered a secondary macronutrient. Because the chlorophyll molecule is built around an atom of magnesium, this element is essential for plant growth and survival.

Although most soils in the U.S. contain adequate levels of magnesium, a few highly-leached areas in the eastern U.S. require additional magnesium. It is more common to find situations where magnesium is high to excessive. Soils with high to excessive magnesium levels are described as clays (the stickiest, heaviest clays are often described as gumbos) because magnesium is part of the crystalline lattice in the clay fraction of the soil.

Because the soil is so dense, excessive magnesium levels cause anaerobic conditions, and nitrogen, phosphorus and potassium levels become deficient. The nitrification process is reversed and nitrite is formed in a process called denitrification. Under these conditions, organic matter is processed into methanol, which is toxic to the microbial population in the soil. The result is lifeless, sticky soil which becomes easily waterlogged during rainy periods and will not take up water when it becomes encrusted during drought.

Magnesium Fertilization

To decrease soil magnesium levels, apply compost and gypsum and grow cover crops. Gypsum (calcium sulfate) should be applied twice the first year and once per year thereafter to leach out the excess magnesium. Apply compost according to the recommendations given under organic matter and return crop residue to the soil when possible.

To increase soil magnesium levels, apply dolomite (a source of calcium and magnesium). Never apply more than 50 lbs. per 1,000 sq. ft. (1 ton/acre) at once. The soil should be retested for magnesium after each application.

Magnesium Soil Test Levels

_____More than 300 ppm: Apply 100 lbs./1,000 sq. ft. (2 tons/acre) of gypsum twice the first year and once per year thereafter. Retest the soil for magnesium every three years. The gypsum should be broadcast on the soil surface and irrigated into the soil.

_____150-300 ppm: Soil magnesium levels are adequate. Apply other amendments, including AGGRAND Natural Fertilizer (which contains some magnesium) at the recommended rates according to soil test levels for other nutrients.

_____Less than 150 ppm: Apply 50 lbs./1,000 sq. ft. (1 ton/acre) of dolomite. Work the dolomite into the soil and retest for magnesium before reapplying.

Calcium

Although calcium (Ca) is considered a secondary macronutrient, it is the most important element in a number of ways. Calcium forms stable soil aggregates, giving the soil the structural capacity to hold nutrients and absorb water and air, promoting prolific microbial and earthworm activity. Calcium also blocks entry of unwelcome invaders, neutralizes toxins, provides a component for cell walls and assists in root development, movement of carbohydrates, protein synthesis and reproductive tissue production.

Soils low in calcium usually have poor structure, reducing water penetration and nutrient-, air- and water-holding capacity. These conditions stress plants and increase susceptibility to insect attack and disease-causing organisms. Excessive magnesium and low calcium tend to compound the situation by further tightening the soil and making it more anaerobic.

Calcium Fertilization

Soil liming increases calcium levels on acidic soils. As the soil pH drops (below 7.0 is acidic), calcium availability decreases. Adding lime to the soil increases pH and calcium over time. If the soil is high in magnesium, calcitic lime (high calcium lime) is applied. If the soil is low in magnesium, dolomitic lime (dolomite) is applied. If magnesium and calcium levels are low, adhere to the recommendations under magnesium fertilization. Once the magnesium reaches an adequate level, apply only calcitic lime.

If the soil is alkaline (pH is above 7.0), the best calcium material to use is gypsum (calcium sulfate). In most cases, calcium levels in alkaline soils are sufficient, but the pH must be lowered to increase calcium availability since it is locked up in salts such as calcium phosphate. Gypsum supplies calcium, but does not lower soil pH. Before gypsum is applied, soils with pH levels over 8.0 must be treated with sulfur or sulfate to lower the pH.

If calcium levels are low, use bulk calcium amendments and apply AGGRAND products that supply calcium through foliar applications and banding in the row. AGGRAND Liquid Lime and Liquid Bonemeal both have high calcium levels. If calcium and phosphorus levels are low, or additional calcium and phosphorus is required (such as with tomatoes), use AGGRAND Liquid Bonemeal at planting in the row and as a foliar feed. If calcium is low and phosphorus is sufficient, or if additional phosphorus is not needed on crops such as hay, turf and pastures, apply AGGRAND Liquid Lime as a foliar feed to supply calcium.

Calcium Soil Test Levels

Once the appropriate calcium source for the particular soil has been selected, use the chart on the right to determine how much of the amendment to apply.

First, determine your cation exchange capacity (CEC) and calcium soil test level. Locate the CEC on the chart that corresponds with your soil test level. If your calcium level is below the level on the chart that corresponds to your CEC, subtract your level from the chart's level. Take the remainder and multiply it by 4. The resulting figure is the amount of calcium that should be applied per acre. For smaller areas, divide the figure by 43 to determine how much of the amendment to apply per 1,000 sq. ft.

For example, if soil CEC is 8.6, round up to 9 (always round to the nearest whole number). The corresponding optimum calcium level on the chart is 1170 ppm. Subtract your level from the optimum level and multiply that figure by 4 to determine the amount to apply per acre.

If the amount of material to apply is over 4,000 lbs. per acre, apply the material as a split application with at least three months between applications. More is not better because micronutrients may become unavailable if too much calcium is added at once. On sandy soils, split into three or four applications; on heavier soils, split into two or three applications. The soil should be retested again in 2-3 years to determine how much the calcium level has increased (it takes time for the calcium to diffuse throughout the soil; it takes less time when the calcium is tilled into the soil profile).

If your soil test report shows a number higher than the optimum level on the chart, calcium levels are sufficient, but micronutrients may become unavailable. Apply compost according to the recommendations under organic matter, and apply elemental sulfur or sulfate if nutrient deficiencies become apparent (stunting, chlorosis between leaf veins, leaf deformities or curling). Apply 2 lbs. of elemental sulfur for every lb. of calcium to be removed. If using sulfate, apply 6 lbs. of sulfate for every lb. of calcium to be removed.

Soil CEC	Optimum Ca Level (ppm)
30	3900
29	3770
28	3640
27	3510
26	3380
25	3250
24	3120
23	2990
22	2860
21	2730
20	2600
19	2470
18	2340
17	2210
16	2080
15	1950
14	1820
13	1690
12	1560
11	1430
10	1300
9	1170
8	1040
7	910
6	708
5	650
4	520

Sodium

Although sodium (Na) is an essential micronutrient, it is never applied as a fertilizer because it is never deficient in the soil. Excessive sodium, however, is a common problem, especially in arid regions and potting media. Excessive sodium inhibits microbial activity and causes plant damage or even death.

Sodium Fertility

Soils high in organic matter are less affected by sodium. The addition of organic matter to western soils decreases the probability of plant damage from soil sodium.

When high levels of sodium are present in the soil, do not add any salty amendments such as salt-based chemical fertilizers like ammonium nitrate or potassium chloride. Because use of salty manures can also be problematic, it is better to apply high quality compost, composted horse manure or pig manure instead of cow or chicken manure.

Growing cover crops is one of the best ways to deal with soils high in sodium. The roots loosen the soil and the additional organic matter helps disperse the sodium so it can be flushed.

When excess sodium is present, it should be leached from the soil periodically by applying calcium in the form of gypsum (calcium sulfate). Broadcast the gypsum evenly over the soil at least twice a year. Once applied, the sodium salt that forms must be leached from the soil with fresh water. After the gypsum has been applied several times, retest the soil to determine if it requires more. Because it may be very difficult to solve this problem if only salty irrigation water is available, it may be necessary to grow salt-tolerant crops.

The application of humates and sodium-eating microbes aids sodium removal from the soil. Humates are broadcast-applied once per year in the granular form to aid in the dispersion of sodium, while microbial products especially formulated for reducing soil sodium can be sprayed onto the soil. Aerobically-digested compost also inoculates the soil with microbes. AGGRAND Natural Fertilizer contains synergistic compounds that disperse sodium and promote microbial activity. Apply AGGRAND Natural Fertilizer twice per year as a spray broadcast application on soils high in sodium.

Sodium Soil Test Levels

_____More than 150 ppm: Do not apply salty amendments or salty irrigation water. Apply high quality compost according to the recommendations under organic matter. Grow cover crops. Apply 50 lbs./1,000 sq. ft. (1 ton/acre) of gypsum twice per year. Retest for sodium after four applications. Spray broadcast 1 qt./3,000 sq. ft. (3 gal./acre) of AGGRAND Natural Fertilizer twice per year. The addition of 10-20 lbs./1,000 sq. ft. (400-800 lbs./acre) of humates once per year in a broadcast application and the addition of microbes during the first two years is also beneficial.

_____100-150 ppm: Do not apply salty amendments or salty irrigation water. Apply high quality compost to the soil according to the recommendations under organic matter. Grow cover crops. Apply 50 lbs./1,000 sq. ft. (1 ton/acre) of gypsum once per year. Retest the soil after four applications. Spray broadcast 1 qt./3,000 sq. ft. (3 gal./acre) of AGGRAND Natural Fertilizer twice per year.

_____Less than 100 ppm: Apply high quality compost to the soil according to the recommendations under organic matter. Spray broadcast 1 qt./3,000 sq. ft. (3 gal./acre) of AGGRAND Natural Fertilizer once per year.

Soil pH

Soil pH measures the balance between hydrogen ions and ions of the base elements (cations), including calcium, magnesium, potassium and sodium. The pH is an indicator of this balance, not a cause of an imbalance. When the pH is not in the optimum range, the base elements must be evaluated.

A pH of 7.0 is neutral, a pH below 7.0 is considered acidic and a pH above 7.0 is considered alkaline. Most plants and all soil life proliferate when the soil pH is between 6.0 and 6.8, or slightly acid. Soils low in organic matter and in high rainfall regions tend to be acidic.

Because the addition of organic matter neutralizes soil pH (adjusts the pH closer to 7.0) over time, any soil with a pH below 6.0 or above 7.0 must have organic matter applied at least once per year. The use of cover crops, the application of high quality compost, the return of crop residue and the application of AGGRAND Natural Fertilizer work together to neutralize soil pH.

Soils with a pH below 6.0 are also deficient in one of the cations, usually calcium. Potassium and magnesium may also be deficient, but in most cases, adding calcium is recommended on acidic soils.

Soils with a pH above 7.0 contain excessive salt levels. Salts are the compounds of cations (commonly sodium) and anions (commonly chloride, sulfate and carbonate). The application of gypsum, sulfur or sulfate used in conjunction with leaching and the addition of organic matter remove the salts and lower soil pH.

Follow individual recommendations under calcium, magnesium, potassium and sodium (if pH is below 6.0 or above 7.0) to adjust soil pH.

Hydrogen

Hydrogen (H) is supplied to plants and soil life through water (H20). Soils with a pH below 7.0 contain mobile hydrogen. Hydrogen levels are maintained by keeping the soil pH between 6.0 and 6.8. Read the section under pH for more details on maintaining soil pH in the optimum range.

Cation Exchange Capacity

Cation exchange capacity (CEC) measures the capacity of the soil for holding cations (calcium, magnesium, potassium and sodium). This capacity is influenced by the level of clay and humus in the soil. As the clay and humus fractions increase, the CEC increases. When the soil has a high CEC, it holds plenty of nutrients that can be released for plant and microbial growth.

CEC is measured by the number of units per unit of soil, and ranges from 0 for pure sand to 100 for pure humus. High quality soil ranges from 18-25, and the best soils can reach as high as 35. Soils below 15 do not hold enough nutrients to support rapid plant growth, and must be fertilized more often to provide plant needs.

Plants growing on low CEC soils respond more readily to frequent feeding than they do on high CEC soils. For example, if the soil CEC is below 15, it may be beneficial to apply AGGRAND fertilizers every three weeks rather than monthly or according to the stage of development. On a very sandy soil (CEC less than 10), AGGRAND fertilizer applications are more effective when applied every two weeks. As a general rule, as the number of AGGRAND applications increase, the fertilizer should be diluted more because the soil can only hold so many nutrients.

When applying lime, gypsum, potassium sulfate and other bulk amendments on low CEC soils, remember to split them into lighter applications. Otherwise, the amendments will be leached from the soil because there are not enough exchange sites to hold them.

The best way to increase soil CEC is by raising the soil's humus level. The use of high quality compost, humates, AGGRAND Natural Fertilizer and cover crops increase CEC. See the section under organic matter for recommendations.

Base Saturation

The exchange sites in the soil contain a reserve of cationic or base elements, including calcium, magnesium, potassium, hydrogen, sodium and a number of micronutrients. The base saturation readings on a soil test show the percentages of the major base elements, not including the micronutrients. All these elements compete for the available sites, and each element must be present in a certain percentage range to create the correct balance. Optimum plant growth and microbial activity are possible when the percentages are balanced, but are still limited by the size of the reserve (CEC).

The optimum balance of base elements is 60-70% calcium, 10-15% magnesium, 2-5% potassium, 10-15% hydrogen and 2-4% sodium and micronutrients. Percentages on the lower end of the ranges are typical of sandy soils, and percentages on the upper end of the ranges are typical of clay soils. With heavy soils, the calcium is often low, while the magnesium is high. When the combined calcium and magnesium saturation is above 80%, the soil resembles cement. Magnesium has a tightening effect on sand, while calcium has a loosening effect on clay. When the soil resembles cement, the magnesium must be removed before the soil loosens up (see section under magnesium). Potassium must be 2-5% for most crops, but perennial crops such as tree crops, vines and canes require 5-7% potassium.

Deficient elements must be added to the soil to increase the saturation percentages. When a deficient element is added, it reduces the percentage of an excessive element. The addition of deficient elements; used in conjunction with leaching of excessive elements, addition of organic matter and microbial stimulation; will bring the soil into balance over time (a number of years). See discussions and recommendations under the individual elements as a guide to bringing soil into balance.

Nitrate Nitrogen

As an essential component of chlorophyll, proteins, enzymes and hormones, nitrogen (N) is extremely important for plant growth. It is present throughout the protoplasm of the cells because it is involved in genetic transfer of information, which controls all the processes of plant growth. Without an adequate supply of nitrogen, plant growth ceases, plants are stunted and will not pass through different successive stages in their development.

On the other hand, if too much nitrogen is present, luxury uptake by plants results in weak cell walls and watery tissue, causing the plants to become more susceptible to attacks from insects and disease-causing organisms. Excess nitrogen inhibits flowering and seed formation and reduces shelf-life, quality and produce flavor.

Nitrogen does not exist as a mineral element in the soil. It must be taken from the atmosphere, which is composed of approximately 78% nitrogen. However, plants cannot use atmospheric nitrogen until it is fixed into an available form such as ammonium or nitrate by free bacteria, algae in the soil and through symbiotic bacteria in nodules contained in the roots of legumes such as alfalfa and beans. Artificial sources of nitrogen (chemical fertilizer) are fixed through the Haber-Bosch process of reacting hydrogen and atmospheric nitrogen under heat and pressure to form ammonium.

Symbiotic bacteria that live in root nodules of leguminous plants have a two-way relationship with their hosts. The bacteria called Rhizobia extract nutrients from the roots of their hosts and fix atmospheric nitrogen into a form that is usable by their hosts and other plants. Symbiotic bacteria are able to fix between 50-400 lbs. of nitrogen per acre per year, with 100 lbs. being the average.

By growing leguminous cover crops such as vetch, crimson clover or fababeans (which are properly inoculated with Rhizobia), at least 100 lbs./acre of nitrogen can be provided per year.

Free bacteria and algae that live in healthy soil can provide as much as 100 lbs./acre of nitrogen per year through fixation. Soil is loosened by adjusting the soil chemistry through practices such as soil liming, enabling these free microbes to fix optimal amounts of nitrogen.

Nitrogen Fertility

Nitrogen use varies wildly between crops. Most garden crops require 150-250 lbs. of nitrogen per year. Lawns, tree crops and vineyard crops require 50-150 lbs. of nitrogen per year. Grains, hay and pasture require 50-100 lbs. of nitrogen per year. In a healthy system with balanced soil chemistry and optimal nitrogen fixation, the need is met with very little supplementation. In toxified soils or soils with imbalanced soil chemistry and minimal nitrogen fixation, the need must be supplemented through the addition of bulk amendments.

With toxified soils, it is best to start weaning the system off chemical nitrogen inputs to allow microbes and earthworms to begin making naturally-fixed nitrogen available (for discussion on this topic, see “Converting to an Organic or More Sustainable System” available through AGGRAND). At the same time the chemical inputs are being decreased, sustainable practices are implemented and higher levels of organic inputs are initially used.

With chemically imbalanced soils, begin by adjusting the soil chemistry through the use of lime, gypsum, sulfur and periodic soil testing to create the proper environment for optimal nitrogen fixation. Sustainable practices must also be implemented, and higher levels of organic inputs must be initially used.

On chemically balanced soils that are not toxified, sustainable practices and moderate levels of organic inputs maintain a balanced, healthy system that supports prolific plant growth.

In addition to following the recommendations for balancing soil, sustainable practices stimulate microbial activity in the soil. Crop rotation, cover cropping, minimum tillage and return of crop residue to the soil are all sustainable practices that should be used according to the constraints of your particular situation.

Plant-available nitrogen is also supplied to the soil through the addition of organic materials such as manures, composts, bloodmeal and cottonseed meal. Apply these materials in broadcast applications before planting to provide nitrogen for the growing season.

To round off a nitrogen fertility program, apply AGGRAND Natural Fertilizer in the row as a soil application at planting to stimulate microbial nitrogen fixation and provide nitrogen directly to the seedlings or transplants. According to plant requirements, continue applying AGGRAND Natural Fertilizer to the soil and leaves with foliar feeding throughout the season.

Nitrogen Soil Test Levels

For heavy feeders such as lettuce, broccoli, onions and corn:

_____Less than 40 ppm: Apply 50 lbs./1,000 sq. ft. (1 ton/acre) of bloodmeal or 100 lbs./1,000 sq. ft. (2 tons/acre) of cottonseed meal (do not use cottonseed meal when pH is below 6.8) in a broadcast application before planting. Apply compost or composted manure and AGGRAND Natural Fertilizer according to recommendations under organic matter. Water-in transplants or band 3 oz./20 ft. of row (3 gal./acre) of AGGRAND Natural Fertilizer at planting. Foliar feed with AGGRAND Natural Fertilizer throughout the season.

_____40-60 ppm: Apply 25 lbs./1,000 sq. ft. (1,000 lbs./acre) of bloodmeal or 50 lbs./1,000 sq. ft. (1 ton/acre) of cottonseed meal (do not use cottonseed meal when pH is below 6.8) in a broadcast application before planting. Apply compost or composted manure according to recommendations under organic matter. Water-in transplants or band 3 oz./20-30 ft. of row (2-3 gal./acre) of AGGRAND Natural Fertilizer. Foliar feed with AGGRAND Natural Fertilizer throughout the season.

_____More than 60 ppm: Apply compost or composted manure according to recommendations under organic matter. Water-in transplants or band 3 oz./30 ft. of row (1-2 gal./acre) of AGGRAND Natural Fertilizer. Foliar feed with AGGRAND Natural Fertilizer throughout the season.

For moderate feeders such as tree crops, vines, cane crops, pastures, hay and lawns:

_____Less than 30 ppm: Use same recommendations as less than 40 ppm under heavy feeders. For lawns apply 1 qt./3,000-5,000 sq. ft. of AGGRAND Natural Fertilizer once a month when grass is actively growing. Return nitrogen to the soil in the form of grass clippings by using a mulching mower. For pastures and hay fields apply 2 gal./acre of AGGRAND Natural Fertilizer after each cutting or grazing when grass begins to grow back or once a month when grass is actively growing on continuously grazed pastures.

_____30-40 ppm: Use same recommendations as 40-60 ppm under heavy feeders. For lawns use same recommendations as less than 30 ppm under moderate feeders. For pastures and hay fields apply 1.5 gal./acre of AGGRAND Natural Fertilizer after each cutting or grazing when grass begins to grow back or once a month when grass is actively growing on continuously grazed pastures.

_____More than 40 ppm: Use same recommendations as more than 60 ppm under heavy feeders. For lawns use same recommendations as less than 30 ppm under moderate feeders.

For pastures and hay fields apply 1 gal./acre of AGGRAND Natural Fertilizer after each cutting or grazing when grass begins to grow back or once a month when grass is actively growing on continuously grazed pastures.

For light feeders such as apples, herbs and vineyards:

_____Less than 20 ppm: Use same recommendations as less than 40 ppm under heavy feeders.

_____20-30 ppm: Use same recommendations as 40-60 ppm under heavy feeders.

_____More than 30 ppm: Use same recommendations as more than 60 ppm under heavy feeders.

Sulfur

Although sulfur (S) is considered a secondary macronutrient, it is found in higher levels than phosphorus in some crops and comparable levels in others. Sulfur is used in the formation of many amino acids and is an essential element in the production of certain proteins and enzymes. Sulfur is required in the production of chlorophyll and serves a vital role in the reduction process in the chloroplasts. It has a significant role in nitrate reduction and the assimilation of free nitrogen (N2) by root nodule bacteria, and it enhances oil formation in crops such as flax and soybeans.

Sulfur Fertility

The major source of sulfur in soil is organic matter. Adequate sulfur is provided by increasing organic matter levels through the addition of compost or composted manures and by growing leguminous cover crops.

Sulfur can be provided through soil applications of bulk amendments, including gypsum (calcium sulfate) and sulfate of potash when soil test levels are low. When calcium levels are also low, use gypsum. When potassium levels are also low, use sulfate of potash.

Additional sulfur is provided through foliar applications on demanding crops such as alfalfa, beans, wheat, corn and cabbage. AGGRAND Natural Fertilizer and AGGRAND Natural Kelp and Sulfate of Potash contain useable amounts of sulfur in the sulfate form for foliar feeding of sulfur-hungry crops.

Sulfur Soil Test Levels

For heavy feeders such as cabbage and corn:

_____Less than 30 ppm: If gypsum or sulfate of potash applications have been recommended in the sections under potassium and calcium, they will supply the necessary sulfur. Otherwise, apply 10 lbs./1,000 sq. ft. (400 lbs./acre) of gypsum per year (split into two applications per year on sandy soils). Apply compost or composted manure according to recommendations under organic matter. Retest the soil every three years to monitor sulfur levels.

For all other crops:

_____Less than 20 ppm: Follow recommendations under heavy feeders in this section.

Micronutrients

Essential plant nutrients required in smaller amounts than the primary macronutrients (nitrogen, phosphorus, potassium) and the secondary macronutrients (calcium, magnesium, sulfur) are considered micronutrients. Zinc, manganese, iron, boron, copper, chloride and molybdenum are essential elements for plant growth, and other elements such as cobalt, selenium, silicon and vanadium appear to have functions in promoting microbial activity and nitrogen fixation or synergistic functions in promoting plant growth. Although micronutrients are just as important as macronutrients, the maintenance of a healthy plant growth system usually supplies enough of these elements.

Proper organic matter management is the best way to guarantee adequate availability of micronutrients. The addition of compost and composted manures, used in conjunction with the application of AGGRAND products, meets the need for micronutrients. In order to supply sufficient amounts of organic matter to the soil, follow recommendations under organic matter.

Soil testing for macronutrients indicates how to balance the soil chemistry to a great extent. Once the base elements are balanced and sufficient organic matter is added to the soil, it may be beneficial to test for micronutrients in order to fine tune the system. For specific recommendations on micronutrients, see the separate AGGRAND guide on micronutrients.

AGGRAND Natural Fertilizer and Natural Kelp and Sulfate of Potash contain micronutrients. Adequate amounts of micronutrients can be supplied by using soil and foliar applications of these products according to the recommendations in this guide.

Should a micronutrient deficiency become apparent on a specific crop even after AGGRAND foliar applications, it may be necessary to use tissue analysis to determine where the deficiency lies. To correct a particular deficiency, a specific amendment can be applied (usually at very low levels compared to other amendments) to the foliage to correct the deficiency.

Foliar Feeding With AGGRAND

Foliar feeding with AGGRAND is up to 20 times more efficient than applying amendments to the soil. The keys to optimizing results when using AGGRAND products are applying them when plants need the extra nutrients, using a biodegradable vegetable oil surfactant (spreader-sticker) to maximize adhesion to the leaf surface and adjusting the pH of the fertilizer solution to maximize uptake and plant use efficiency. Apply in early morning or late evening, and do not apply before or after rainfall or irrigation.

Plants require extra nutrients during transplanting, early growth and development, prebloom, early bloom and fruit formation. Foliar applications are effective where a soil chemistry imbalance, cold soils or low soil fertility limit the root uptake of nutrients. Most plants respond to foliar applications when they are timed to coincide with seedling emergence (3-6″ in height after 2 to 4 true leaves have formed), 2-3 weeks before first bloom (legumes such as snap beans or soybeans), first bloom (tomatoes, cucumbers, melons), runnering (cucumbers, melons), cluster formation (tomatoes) and fruit fill (tomatoes, melons, cucumbers). When AGGRAND Natural Fertilizer and Natural Kelp and Sulfate of Potash fertilizers are applied before drought, frost, insect attack or the onset of disease-susceptible stages, the effects of the stress will be reduced or eliminated.

Some growers apply AGGRAND fertilizers on a calendar-based approach, up to eight times per season. Apply fertilizers according to recommendation rates provided earlier in this guide for applications given every 3-4 weeks. A 1-4% dilution rate (1.25-5 oz. AGGRAND per gal. of water) is sufficient for foliar applications. Use more concentrated fertilizer concentrations on heavy feeders and low fertility soils, but never exceed 4% because it could cause foliage damage. On sandy soils reduce the rate by ¼ to ⅓ and apply every 2-3 weeks (reduce by ⅓ and apply every 2 weeks for heavy feeders on sandy soil). When applying AGGRAND products every week, split the application rate in half (1% dilution rate).

AGGRAND Natural Fertilizer and Liquid Bonemeal products can also be applied to promote flowering, fruit and seed formation. Apply when the plants have reached the phase (size, age, time of year) when flowering is possible.

AGGRAND products and Dealership information are available from your local AGGRAND Dealer.

AGGRAND®

AMSOIL INC., Superior, WI 54880 (715) 392-7101 Fax: (715) 392-5225, (715) 392-5267 Printed in U.S.A. G2792 9/10